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Missing players: Phonology and the past-tense debate☆

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Abstract

The proposition that the mental lexicon is a 'dual route' system, advanced by Pinker and others to account for regular and irregular morphology, overlooks the important fact that morphological regularity correlates inversely with phonological regularity – 'regular' past-tense *beeped* being phonologically *ir*regular (exceptional syllable), while 'irregular' past-tense *kept* is phonologically just regular.

I argue that the correlation, which is general, can only be captured under a single – rather than 'dual' – architecture, and an associational – rather than rule based – theory of morphology. Where word-to-word associations are strong, morphology looks regular and phonological alternations are inhibited, making phonology look irregular. In a system in which regularities are attributed to 'rules', rules should be able to coexist with other rules, and morphological and phonological regularities should correlate directly, rather than inversely.

Keywords: Lexicon; Memorization; Optimality; Phonology; Morphology; Regularity; Rules; Underlying representation

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1. Introduction

In this article I will argue that a crucial interaction between principles of sound structure – phonology – and principles of word-formation – morphology – has been overlooked in the long-standing debate on the English past-tense, and that, once that interaction is factored in, the class of possible solutions to the problem of regular versus irregular morphology is sharply reduced, ruling out extant 'dual route' models.

For over ten years now, a debate has opposed two groups of psycholinguists, centering on the nature of the mental representation of the English past-tense, more specifically on the nature of the distinction between regular past-tenses, like *beep/beeped*, and irregular past-tenses of various kinds, among them *keep/kept*. In its most general version, the debate concerns the nature of the distinction between regular and irregular morphology in natural language. At the historical roots of the debate is the coming of age of connectionism in the mid-1980s and the claim of Rumelhart and McClelland (1986) that a connectionist net could adequately simulate children's various stages of acquisition of the English past-tense, yielding a similar 'U-shaped curve', with initial correct acquisition of irregulars, followed by over-regularization, followed by correct production of irregulars again. The debate has generated two basic positions. One is that knowledge of regular and irregular morphology is fundamentally uniform: Bybee (1985, 1988, 1996); Plunkett and Markmann (1991); MacWhinney and Leinbach (1991); Seidenberg (1992, 1997); Daugherty and Seidenberg (1994), and others. Theoretical characterizations of this position are referred to as 'single route' models. The other position is that the two types of knowledge are fundamentally different, and its theoretical characterizations are referred to as 'dual route' models: Pinker and Prince (1988, 1992); Pinker (1991); Fodor and Pylyshyn (1988); Lachter and Bever (1988); Clahsen and Rothweiler (1992); Marcus et al. (1995); and others. Single route models utilize a connectionist or associationist-type architecture. Dual route models generally accept the associationist-type approach to irregular morphology, while at the same time attributing regular morphology to a symbolic-type word-formation rule, whose effects are more categorical than associational systems can produce.

Within traditional generative linguistics, the study of morphology has been consistently intertwined with that of phonology. This is especially true of the Lexical Phonology tradition (Kiparsky, 1982a,b) of the 1980s. In the context of the above debate, concern for phonology has been lacking, however. The goal of this paper is to reassert its significance, and outline an approach to morphology which both takes account of it, and has precise consequences for the above debate. A quick preview of the significance of phonology is given by simply considering that a form like *beeped*, uncontroversially 'regular' as a past-tense, is nonetheless phonologically quite irregular, by virtue of its inordinately large syllable, containing both a long vowel and two consonants. On the other hand, *kept*, an 'irregular' past-tense, is phonologically just regular, the long vowel of *keep* shortening for manifestly phonological reasons: staying within the limits of canonical

syllables.[1] These facts are not accidental, the inverse correlation between regular morphology and regular phonology being quite general and demanding explanation. While the 'single route' models that have been proposed provide no explicit account of the phonological facts, it is the 'dual route' approach that seems inherently unable to do so. If regular morphology is due to a symbolic rule, the question is why does the phonology, which is active elsewhere, become inactive just when the symbolic rule is involved? The only answer to this would be that what we call 'phonology' is just a complex set of semi-regularities, to be properly ascribed to the associational system, along with irregular morphology, and for this reason absent from the 'symbolic' route. This conclusion is simply incorrect, however, as we see below.

The model that I propose is one that uses the general resources of Prince and Smolensky's (1993) 'Optimality Theory' (OT), but in a general architecture similar to that of Bybee's (1988, 1995, 1996) 'Network' model. It consists of three sets of interacting, violable, constraints expressing the roles, respectively, of word-specific memorization, principles of phonology, and word-to-word association. Upward reranking of the associational block of constraints will have the effect of simultaneously inhibiting both the phonology and word-specific memorization, the latter being the essence of morphological 'irregularity', and thus capture the noted correlation.

The paper is organized as follows. In Section 2, I establish the general correlation between regular morphology and inoperative phonology. In Section 3, I introduce the basic theoretical machinery – the adapted version of OT that has no 'underlying representation' and relates words to one-another directly, surface-to-surface. Section 4 further develops the system of surface-to-surface associations identifying a central principle whose consequences include the clustering of properties formerly captured under the primitive notion of 'morpheme', and the type of combinatorial invariance formerly attributed to word-formation rules. Section 5 returns to some issues left unsettled earlier, and section 6 shows how the complementarity of morphological and phonological regularity follows from the proposed system featuring a single basic architecture, but not from a 'dual route' approach. Section 7 argues that, under the proposal, the number of regulars will be a determinant of further regularity, a factor controlling certain competitions between affixes and their stems, and that the 'self-feeding' nature of regularity is responsible for the fact that morphological systems seem to be either sharply regular or substantially irregular, with little in between. Section 8 concludes.

2. English lexical strata

The debate on the English past-tense has focused on an artificially limited subdomain of English morphology. Earlier work in linguistics had established different

[1] As Yang (2000: Section 4.3.5) points out, acquisition of this class of 'irregulars' is substantially faster than that of other classes, like that of *sing/sang*, where the alternation is not phonologically predictable. As Yang argues, phonology thus needs to be factored in – exactly the present claim.

morphological classes, not only for the past-tense, but for the English lexicon at large. In particular, the approach called 'Lexical Phonology' had identified several levels or strata within the lexicon, interpretable as different stages in a sequential derivation. The clearest fault line, however, was found to be that between 'Level 1' and 'Level 2' formations, the former consisting of words derived by means of Latinate affixes, like *-al*, *-ic*, *-ous*, *-ive*, etc., while the latter consists of those derived by means of Germanic-type affixes, like *-ness*, *-less*, *-ful*, *-hood*, etc.[2] Other criteria provide the proper classification, though, etymology being only a fairly general correlate. A main characteristic of Level 2 morphology is that it is fundamentally regular and productive, while its Level 1 counterpart is rather irregular and of limited productivity – just the difference between regular and irregular past-tense. The various types of irregular past-tense are perhaps at the outer fringes of Level 1 in this respect, by being particularly unproductive. They were nonetheless classified as Level 1 in Kiparsky (1982a). In contrast, the regular past-tense may perhaps be placed at the outer fringes of Level 2 as being particularly productive. Kiparsky (1982a) classified it as 'Level 3', but I will not draw that further distinction here, and assume only two major classes. In what follows, I will use the terms 'Level 1', 'Level 2' as mere descriptive labels, without implying any type of derivational account.

By extending the empirical domain from the past-tense to the more general Level 1/ Level 2 distinction, we can more clearly see the inverse correlation between regular morphology and regular phonology noted above and stated in (1).

(1) Lexical sectors that are morphologically irregular tend to be phonologically regular, and vice-versa.

Morphological irregularities in Level 1 formations include the following:

(2) a. personify+ation ⇒ personifiCation
b. problem+ic ⇒ problemATic
c. horizon+al ⇒ horizonTal
d. president+al ⇒ presidentIal
e. habit+al ⇒ habitUal
f. rabbi+ic ⇒ rabbiNic
g. compel+ive ⇒ compUlSive

In each of the examples in (2), the morphologically derived word is not completely faithful to the combination of morphemes, as indicated by the capitalized portions. In some cases, an insert appears between the stem and the affix, and its shape is not fully predictable. Considering for instance the case in (a), while it is a general fact that verbs in *-ify* nominalize in *-ication*, that sequence is clearly not a morpheme. Rather, it results from a combination of factors which are partly phonological and

[2] The simpler, two-level organization of the lexicon emerges in later work in Lexical Phonology, most notably Booij and Rubach (1987).

partly analogical to other formations. The phonological factors concern the shortening of the final stem vowel: *[ay]⇒[ɪ]* – a phonological regularity, as we see below, and the insertion of *c* to improve syllable structure (provide a syllable onset). The presence of phonology in (2) is in fact just an instance of (1). The specific choice of *c* as the inserted consonant in (2a) is not phonological, however, but is rather based on the analogy with items like *complication*, where the sequence *ication* is morphologically legitimate, arising from the combination of a stem in *-icate* with *-ion*. In fact, the sequence *-ation* in (2a) and many other items is itself generally unpredictable and analogical, as with *expect-at-ion* (**expect-ion*, but *correct-ion*); *limit-at-ion* (**limit-ion*, but *prohibit-ion*); *comput-at-ion* (**comput-ion*, but *constitut-ion*). The basis for such analogy is provided by formations from verbs in *-ate*, where such *-ation* sequences are morphologically legitimate. There are similar extensions in *-ition*, as in *oppos-it-ion* (**oppos-ion*, but *infus-ion*), analogical to *inhibit-ion*, etc. A review of the other cases in (2) reveals similar factors at work, suggesting that when morpheme combine 'irregularly' or unpredictably, the irregularity is typically not random, but rather: (i) It may be phonologically driven; and/or (ii) it may comply with a pattern that independently exists in the lexicon, sometimes for independent morphological reasons, sometimes idiosyncratically. Point i) reduces to the generalization in (1), while point (ii) is an effect that I will term 'lexical conservatism' after Steriade (1997b, 1999), and that I will return to below.

If this characterization is correct, then indeed the 'irregular' past-tenses belong with Level 1 morphology, since they share the above characteristics. They exhibit general unpredictability: *sink/sank*, but *link/linked*; they give rise to subregularities: *ring/rang*, *sing/sang*, etc.; the mismatch between base and derived form may be phonologically driven. So, the noted *keep/kept* is in fact morphologically 'irregular' only by being phonologically regular (see fn. 1). Specifically, and simplifying slightly here, the maximal syllable in English is a heavy syllable CVC or CV:, where 'V:' is a long (diphthongized) vowel. To this can be added a one-consonant appendix word-finally, whence, regularly, *[kee]<p>*.[3] When a past-tense morpheme *-t* is added, the limitations on syllable size will force the vowel to shorten, whence, still regularly, *[kep]<t>*. Morphologically 'regular' *[bee]<p>/ [bee]<p>t* is thus phonologically irregular, by the extra *t*.

Another characteristic of the irregular past-tenses, limited productivity, also places them with the Level 1 lexicon at large. So, just as *-t* gives *kept* from *keep* but not **bept* from *beep*, so *-al* gives *parent-al* from *parent*, but not **student-al* from *student*. Similarly, *-ous* gives *cavern-ous* from *cavern*, but not **tavern-ous* from *tavern*. The present motivation for extending the discussion from the past-tense to the Level 1/ Level 2 distinction at large is – again – that this will enhance the opportunity to observe the differential behavior with respect to phonology, which will then

[3] In Burzio (1987, 1994a,b) I analyze the word-final appendix, as well as – more generally – any word-final consonant, as a syllable with a null nucleus, hence *[keep]<pø>*. The main motivation for this analysis is that such syllables play a role in stress. Identical conclusions are reached in Harris (1994: Ch. 2), based on a detailed discussion of distributional regularities, with respect to which such consonants pattern with onsets rather than with codas.

play a role in limiting the range of possible analyses. Note that Pinker and Prince (1992), while arguing for a 'dual route' approach, essentially endorse this extension of the relevant domain beyond the irregular past-tense:

(3) "A more distant goal would be to see if such an interaction between linguistic representation and superimpositional memory can be applied to the notoriously capricious productivity of much of English derivational morphology, especially Latinate affixation and allomorphy attributed to Level 1 in Lexical Phonology, and other partially productive morphological processes." (Pinker and Prince, 1992: 229)

While one may choose to refer to the English Level 1 lexicon as 'capricious' as in the quote, there is in fact nothing unusual about it. Major sectors of the lexicon of other languages appear to have just the same properties, morphological irregularity being a well-known fact of life. Before turning to the phonological characteristics of the Level 1 lexicon, we must note two other types of 'irregularity'. One is semantic. Level 1-derived forms have various degrees of semantic independence from their bases. For instance *regrett-able* does not have the predicted meaning 'that *can be* regretted', but rather means 'that *is to/must be* regretted'. Similarly, *electric-ity* does not have the expected meaning 'condition of being electric', and so forth. The other irregularity is represented by 'bound' stems, as illustrated in (4).

(4) a. ?+ous ⇒ STUPEND+ous
b. ?+al ⇒ ARBORE+al
c. ?+ic ⇒ ELECTR+ic
d. ?+able ⇒ INEVIT+able
e. ?+ist ⇒ ANTAGON+ist

In each of the cases in (4), the stem does not exist as an independent word. This phenomenon is rather pervasive, the incidence of such cases for each of the 'Latinate' affixes being on the order of 20%. The latter two irregularities are not shared by the irregular past-tenses, which always have a corresponding present/infinitive base, and also seem semantically faithful to that base. I assume that this will ultimately follow from independent factors and not invalidate the proposed extension. Intuitively, formation of a past-tense involves a rather specific and narrow semantic operation. Importantly, no change in lexical category occurs. Hence, there is a much greater degree of semantic correspondence over present/past-tense pairs than over the pairs created by the Level 1 derivational affixes, and this could plausibly be responsible for ensuring both that a past-tense always has a base (i.e. a present tense), and that its semantics is faithful to it. To put it differently, present/ past-tense relations exist within a narrow semantic space, and this is the likely reason why they are semantically regular even when they are irregular in form. A theory that ties regularity to proximity is developed below.

The following table summarizes the various dimensions of 'irregularity' of Level 1 morphology.

(5) *Level 1 Morphology*

a. Morphological irregularity:	personifiC-ation, problemAT-ic, horizonT-al, presidentI-al, habitU-al, rabbiN-ic, ...
b. Bound stems:	STUPEND-ous, ELECTR-ic, INEVIT-able, ANTAGON-ist, ...
c. Semantic irregularity:	*regrett-able*: 'that **can* be regretted'; *electric-ity*: *'the condition of being electric'; ...
d. Low productivity:	*student-al, *tavern-ous, *suspend-age, ...

Now, the Level 2 morphology, represented by most of the 'Germanic' affixes, like *-ful, -less, -ness, -hood*, differs systematically with respect to all of the properties in (5). Morphological irregularity and bound stems are absent with rare exceptions, like *hap-less, reck-less, bash-ful*. Semantic irregularity seems also rather subdued, though perhaps not completely absent. E.g., the semantics of *event-ful* does not seem to be totally compositional. Productivity is without doubt much greater. Hence, there is clearly a qualitative difference between Level 1 and Level 2 lexicon, and the distinction seems to be in terms of item-specific memorization playing a substantial role in the Level 1 lexicon, while playing a distinctly smaller or negligible role in the Level 2 lexicon, which thus appears to be produced in a quasi-mechanical fashion by combining morphemes. Indeed, this summary characterization based on the role of item-specific memorization seems applicable to the irregular versus regular past-tense distinction just as well, and to capture the bulk of the experimental evidence that the debate has produced over the years.

The two sides of the debate seem to agree on the nature of the irregular past-tense. So Marcus et al. (1995: 195) note that: "[t]hus, there is a broad consensus that pattern associator memories have a role in irregular inflection" (see also Pinker, 1991). If the above extension is correct, however, the Level 1 lexicon as a whole would be the product of a pattern associator. Given the evidence presented just below, the question will be how to relate rich phonological alternations to the presence of a 'pattern associator'.

The Level 1 lexicon is rich with alternations like the ones in (6).

(6) *Level 1 Phonology*

a. Vowel shortening	na:ture/natur-al; admi:re/admir-able; cri:me/crimin-al, explain/explan-ation; fi:ni:te/in-finite; cy:cle/bi-cycle; ...
b. Velar softening	authentic/authenti[s]-ity; critic/criti[s]-ism; ...
c. Re-stressing	párent/parént-al; títan/titán-ic; ...
d. 'Base(only)-neutralization'	condem[ɱ]/condem[n]-ation; lon[ŋ]/lon[g]-er; ...
e. De-syllabification	cent[ɽ]/centr-al; met[ɽ]/metr-ic; cyc[ɻ]/cycl-ic; ...
f. Flapping (Am. English)	anecdote/anecdo[ɾ]-al; feud/feu[ɾ]-al; ...

In (6a), the base words have 'long', i.e. diphthongized vowels (length marks are added to the orthography for explicitness). In the derived words, these vowels shorten. Traditional work in generative phonology had distinguished several types of shortening, among them the 'tri-syllabic' one (in the third syllable from the end) of *natural*, etc. I have shown in Burzio (1993, 1994a, 2000a), however, that aside from shortening in closed syllables (as in the noted *kept*, as well as *receptive*, *intervention*, etc.) there is a single and pervasive type of shortening, so that all of the cases in (6a) instantiate the same phenomenon.[4] In (b), the velar stop [k] turns to coronal continuant [s] before the high front vowel [ɪ], similarly to phenomena that exist in many languages. In (c), the stress, which in English is calculated from the end of the word, not surprisingly moves forward when the suffix is added. In (d), a consonant appears in the derived word, but not in the base word (where it neutralizes to zero). The reason for this is a general prohibition on certain final consonant clusters. In (e), certain syllabic sonorants, permitted in general only word-finally, lose their syllabicity – again predictably – when a suffix follows. Finally, in (f), a coronal stop [t] or [d] turns into an alveolar flap when between a stressed vowel and another vowel.[5] To the extent that the alternations in (6) are regular and expected, their systematic absence in (7) except for the one in (f) is surprising.

(7) *Level 2 Phonology*

a.	No V shortening	deli:ght-ful; deceit-ful; cri:me-less-ness; dri:ver-less; ...
b.	No velar softening	traffick-ing; politick-ing; ...
c.	No re-stressing	méaning-ful; éffort-less; ...
d.	Neutralization in derived forms	condem[m̩]/condem[m̩]-ing; lon[g̩]/lon[g̩]-ing; ...
e.	No de-syllabification	cent[ɾ̩]/cent[ɾ̩]-ing; met[ɾ̩]/met[ɾ̩]-ing; cyc[l̩]/cyc[l̩]-ing (but also cyc[l]-ing); ...
f.	Flapping (Am. English)	write/wri[ɾ]-ing; pit/ pi[ɾ]-ed; allude/allu[ɾ]ed; ...

In the debate over the English past-tense, each side has made a proposal on the nature of the distinction between regular and irregular morphology, but neither has provided any clear means to handle phonological facts such as those in (6) and (7). The only immediate recourse for either side would be to suggest that the alternations in (6) are on a par with the ones in (2) above, that is that they are just different types of morphological irregularities, which, like others, nonetheless fit into patterns of sub-regularity. Ultimately, there may be one grain of truth in this view, but only one. On the one hand, it may not always be easy to distinguish between the two types of

[4] An earlier and often cited attempt to unify different types of shortening is that of Myers (1987). The unification argued for in Burzio (1993, 1994a, 2000a) is considerably farther reaching, however.

[5] On the exact conditions for flapping, see Harris (1994; Section 4.7).

alternation. On the other, however, it often is. By and large the alternations in (6) are ultimately related to properties of Universal Grammar (UG), while the ones in (2) are largely based on accidents of the complex history of English. This is why the regularities in (6) have counterparts in other languages, while the ones in (2) do not, except of course in languages whose histories intersect with that of English. So, the vowel-shortening of (6a) stems from the fact that long vowels are cross-linguistically more 'marked' or rare than short ones, and are for this reason eliminated in the formations in (6a) as I argue below. Sequences velar-front vowels are also often restructured as in (6b) cross-linguistically, as already noted, although the English alternations may in fact be partly fossilized, witness forms like *criti[s]-ize*, where velar softening occurs despite the back vowel (of the diphthong *[ay]*, still a front vowel through Middle-English). Stress and syllabification, involved in (6c,d,e) and in *[kee]<p>/ [kep]<t>*, are facts about languages at large, though partly modulated by English-specific choices. The different bases (UG vs. historical accident) are the likely reason why the regularities of (6) are – within English – considerably more general than any of the subregularities in (2). These facts challenge both types of proposals advanced within the debate. For existing single route models, assuming that they are indeed capable of dealing with both partial and more categorical types of regularity, the regularities in (6) would presumably not be a challenge in themselves, but rather by virtue of the inverse correlation in (1) above. One needs to properly integrate the effects of pattern association with those of the phonology in a way that gives the complementary distribution in (1), a task that I will in fact carry out below. For dual route models, the problem is rather more endemic. The insistence that regular morphology is due to a symbolic rule overlooks the fact that the same tradition of generative linguistics that had introduced 'rules' for regular morphology, had also introduced 'rules' for regular phonology. If regularity is 'rules' and semi-regularity some type of pattern association, then one will expect – if anything – that the two types of 'rules' should peacefully coexist over the same sector of the lexicon – just the opposite of the generalization in (1).[6] Note as well that an attempt to segregate the phonology into the pattern associator by brute-force would be doomed, given the fact that phonological alternations are not *totally* absent from the domain of regular morphology, as shown by (7f) and by the parenthesized variant in (7e). In addition, there is also regular phonological alternation in the regular past-tense suffix itself, that has the allomorphs [-t], [-d], [-ɪd]. Hence, the conciseness of the generalization in (1) above belies the fact that there are no wholesale solutions to the problem of the phonology–morphology interaction.

The conclusion is that, while the debate on the English past-tense has been lively and productive, having lately extended as well to morphological systems of other

[6] Hence, while the position taken by 'dual route' proponents may seem conservative relative to the generative tradition for its defense of 'symbolic rules' it is in fact, and perhaps unwittingly, quite radical once phonology is taken into account. The reason is the concession in (3) above that the English Level 1 lexicon, traditional domain of phonological rules, is now to be properly characterized by a theory of associations.

languages, ultimately, the problems posed by morphology cannot be seriously addressed without a concrete theory of phonology and an account of their interaction – the task to which I now turn.

3. Optimality and surface-to-surface relations

3.1. Synopsis

My proposal is based on the hypothesis of Burzio (2000a) that lexical organization consists of the three components in (8), each of which is represented by a set of ranked, violable constraints.

(8) a. Memorization
b. Phonology
c. Word-to-word associations

Taking it as a virtual definition that 'irregular' morphology reflects a larger role for item-specific memorization (8a), it follows from this approach that assigning top rank to the constraints of the associational component (8c) will simultaneously suppress the effects of the other two components, hence accounting for the correlation between irregular morphology, due to (8a) and regular phonology, due to (8b). In other words, I take 'regular' morphology to be a high-ranked form of word-to-word association. As such, it will be intolerant of *mis*-associations, whether due to the effects of the phonology or to item-specific memorization. To illustrate, I take the regular past-tense to be characterized by the implicational cluster in (9), where I abstract away from the [-t], [-d], [-ɪd] allomorphy.

(9) a.	Meaning:	'past-tense of X'	Conditions:
b.	Form:	X-ed	i. a ⇔ b
c.	Base:	X = verb	ii. b ⇒ c

The biconditional in (9i), re-stated as in (10a) below, renders the traditional notion of 'morpheme' – a fixed association of form and meaning, while the conditional in (9ii), re-stated as in (10b) and specifying the affix's environment of occurrence, has essentially the effect of a traditional word-formation rule or subcategorization frame.

(10) a. 'past-tense of X' ⇔ X-ed (≈Morpheme)
b. -ed ⇒ / $_{\text{verb}}$] ___ (≈Word-formation rule)

The difference with the more traditional notions of generative work is that the conditionals in (10) are taken to be violable. The violability of (10b) will allow for the structure preceding *-ed* to deviate from that of the relevant verb, as in (7f) *pi[ɾ]-ed*, which deviates from *pi[t]*. Similarly, the violability of (10a) will allow the affix itself to vary in form, whence the [-t], [-d], [-ɪd] allomorphy. In contrast to (10b),

the kind of 'symbolic' word-formation rules proposed by Pinker and others are inviolable devices. Apparent inviolability can be attained for a constraint like (10b) by assigning it a high-rank. This will appropriately exclude both types of hypothetical structures in (11).

(11) a. * compuls-ed (compuls ≠ compel)
b. * bep-ed ([bept]) (bep ≠ beep)

The type of structure in (11a) is the one that should be possible if word-specific memorization was able to override the identity between the stem and the independent word imposed by (10b) similarly to what obtains in *compuls-ive*. The structure in (11b) would be expected if the phonology were able to have it its way accepting only normal syllables, as in *kept*. Evidently, the phonological constraints that give *pi[ɛ]-ed* are themselves higher-ranked than (10b), which is disallowing (11b) **[bept]*.

The framework for the present analysis is a variant of the Optimality Theory (OT) of Prince and Smolensky (1993), henceforth 'P&S', with origins in the independently developed approach of Burzio (1991, 1993, 1994a, b), which, like that of P&S, had also introduced violable constraints. The intuitive labels in (8) above – in fact – stand, respectively, for the terms in (12), familiar in the OT literature.

(12) a. Input–Output Faithfulness (IO-F)
b. Phonological Markedness (PHON-MARK)
c. Output-to-Output Faithfulness (OO-F)

The present framework differs from other work in OT by maintaining that direct relations among surface forms of words, regulated by (12c), are not only necessary, as argued extensively in Benua (1997), Burzio (1994a) and others, but also sufficient for an adequate account of morphology and allomorphy, thus dispensing with the traditional generative notion of 'underlying representation', and yielding an overall architecture like that of Bybee's (1985, 1988, 1995, 1996) 'Network model'.

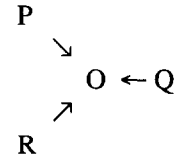
3.2. Input–output faithfulness versus markedness

As with any other grammatical system, an OT grammar provides an Input-Output mapping. Let us assume that, with words that do not manifest any morphological dependency from others, like, say, *dog*, or *America*, the 'OO-F' constraints of (12c) are not relevant, and the mapping is done solely by the interaction of IO-F and Markedness. We can think of that interaction as comparable to the one involved in an object being pulled by a spring over a horizontal surface. As the spring's pull is obeyed, the spring's force grows weaker. Equilibrium is reached when the spring's force is equal to or less than the one due to the friction between the object and the surface. This model performs a simple calculation in which the input is the position at which the object is originally placed, and the output is the ultimate resting position. Input–output faithfulness is the friction (that would hold the object in place), and

Markedness is the effect of the spring, that penalizes far-to-reach positions.[7] This model must be applied on each dimension in the multidimensional space relevant to the mental representations of words. In psychological terms, we can take IO-F (friction) to represent memory, and Markedness (springs) to represent a set of inherent biases, provided by UG, and refined during language acquisition.

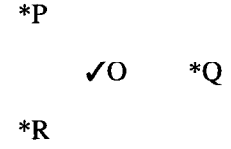
While in much work in OT the notion of 'input' is closely identified with the traditional 'underlying representation' (UR), that is not true in the present framework, which dispenses with UR. There are two notions of 'input' that need to be distinguished, however. One pertains to lexical storage. Given an actual output form like *[əmérəkə]*, the question is what is the lexical form that is actually stored corresponding to that output. The answer given here is that the stored form is in fact the output form itself. This is the move that ultimately dispenses with underlying representation as discussed below. The other notion of 'input' pertains to P&S's notion of 'base' and the principle of the 'Richness of the Base'. On that notion, an input can be any representation at all, or any point in the relevant multi-dimensional space. In this sense, the base (set of inputs) is 'rich'. An OT-type grammar provides a mapping from each possible input to a corresponding output. Since the set of outputs is a subset of the set of possible inputs, that grammar performs a set of 'neutralization' operations, as visually illustrated in (13), where each of P, Q, R as inputs, all map to O as an output, as does O itself.

(13) *Input–output mappings in OT*



This 'neutralization' effect is also displayed by our mechanical model: the object's resting position can be reached from a variety of initial positions, including the resting position itself. In this respect, an OT grammar contrasts with a grammar based on inviolable constraints, which does not perform any real mapping as in (13), but rather only acts as a 'filtering' device, the corresponding illustration being as in (14).

(14) *Input–output filtering by inviolable constraints*



In (14), input O is sanctioned to be a possible output, while P, Q, R are sanctioned not to be, but without any indication of how they could be 'repaired'.

[7] The object's inertia is not relevant here.

The above notion of 'input', corresponding to the class of representations that the grammar can evaluate, is not dispensed with here, since it is simply part of any definition of 'grammar'. Unlike the earlier notion of input, pertaining to lexical storage, the latter is not directly relatable to the traditional UR. The reason is that traditional URs did not satisfy P&S's 'Richness of the Base' principle. Rather, URs were thought to abide by various restrictions, both on segmental inventories and on the structure of morphemes ('Morpheme Structure Constraints'). Thus they were in effect sets of outputs of some – often only implicit – constraint-based grammar (whose input might well have satisfied the 'Richness of the Base').[8]

Returning to our specific output form *[əmérəkə]*, an appropriate OT grammar of English is likely to produce that form from the input */amerika/*, in which all the vowels are full and there is no stress, as well as from */əmérəkə/*, identical to the output itself, or from various other structures, like */ǽmerəkə/*, with the wrong stress, */əmmérəkə/*, with a geminate *m*, and others, just as each of P, Q, R, O, maps into O itself in (13) above. The question then is: which one of these candidate inputs is the one that is actually stored? P&S answer this question by means of the 'Lexicon Optimization' hypothesis, according to which the actual/ stored input is the one that yields the observed output with the minimal amount of constraint violation. It is easy to see that such 'optimal' input is in fact the output itself. The reason is that the only constraints that can discriminate among inputs are the Input-Output faithfulness constraints. The input that equals the output (O in (13)) satisfies all of those constraints by definition, and is thus automatically the optimal one. Adopting P&S's 'Lexicon Optimization' one can then say that there is only one representation of *[ðmérðkð]* – the surface form, which is both input and output, with no need for a separate underlying representation. The grammar effectively works on such representations as a 'checking' device. It does so by taking them as inputs, and rendering them unchanged as outputs, when they 'check'. When a form does not 'check', it is repaired. Under Lexicon Optimization, storage will then reflect the repair. The present innovation (with roots in Burzio, 1991, 1993, 1994a,b) consists in extending P&S's Lexicon Optimization to morphologically complex words, as discussed next.

3.3. Output–output-faithfulness versus underlying representation

Most work in OT abandons the Lexicon Optimization hypothesis when it comes to allomorphy and takes the input in those cases to be no longer the output itself, but rather the traditional UR . The diagram in (15) illustrates.

(15)	Input (UR)	/pærent/	/pærent+æl/
		⇓	⇓
	Output (Surface)	[pǽrənt]	[pərént+əl]

[8] OT effectively unifies into one the two grammars of the earlier tradition: the one that yields URs (from a 'rich' base or input), and the one that yields surface representations from URs. The main argument for this unification is given by the 'duplication problem' – the observation that the constraints needed to characterize URs play a role in the 'repairs' (from UR to surface).

This is the traditional generative view of allomorphy, by which there is a unique 'morpheme' */pærent/* in UR, which is mapped into two different surface manifestations *[pǽrənt]*, and *[pərént..]* (the affix provides the contextual difference that determines the different stress, and in turn the different pattern of vowel reduction). In the mainstream OT version of this, the UR constitutes the input, and each surface allomorph is calculated from the common input */pærent/* via IO-F and Markedness, Lexicon Optimization being inapplicable here as noted. I point out in Burzio (2000a), however, that, since the notion of faithfulness (violable identity) is transitive, the double application of IO-F from a common UR in (15) simply translates into the two surface allomorphs being faithful to each other. One can then, at least in principle, postulate direct, surface-to-surface faithfulness of allomorphs, hence dispensing with UR, not just with morphologically unrelated words but altogether (provided that one can suitably define the notion 'allomorph', a point to which I return). The overall structure of the grammar would on this view consist of the two components of standard OT: IO-F and PHON-MARK, to which a third component: OO-F, working analogously to IO-F, is now added, in the same general architecture of the system, which is parallel, all constraints applying simultaneously to a single (surface) representation.

It has been shown in Benua (1997), Burzio (1994a) and other work that such direct surface-to-surface faithfulness is not only a possible part of the theory (by the transitivity just noted) but indeed a necessary one. The reason is that allomorphs tends to share not only those features that a common UR would provide, but also those that it would not, as in the following examples.

(16) I. a. napóleon
b. napòleón-ic
II. a. américan
b. américan-ist

In both (I) and (II), the derived word's stress pattern is detectably influenced by that of its 'base'. The reason is that, in (Ib) the secondary stress would otherwise be expected on the first syllable, as in *àbracadábra*, while in (IIb) the primary stress would be expected on the antepenultimate rather than the pre-antepenultimate syllable, as in *antágonist*, etc. On the other hand, in the bases, the stress is just regular, antepenultimate in both cases. The phonology of stress is thus not applying regularly in the (b) cases, but is rather partially 'mis'-applying. The exact nature of the misapplication reveals that the derived forms are faithful to the surface forms of their bases directly, rather than just indirectly through a UR as in (15). Such direct faithfulness is termed here 'Output-to-Output faithfulness' following Benua (1997). Other near-equivalent terms are the 'Metrical Consistency' of Burzio (1991, 1993, 1994a,b), and the 'Uniform Exponence' of Kenstowicz (1996). OO-faithfulness (OO-F) constraints will yield the noted misapplications of phonology when they dominate the relevant PHON-MARK constraints. This type of account will be extended below to the rather massive misapplications of phonology we noted for the Level 2 affixes, while the affixes in (16) are Level 1, yielding preservation of stress only

under special circumstances (cf. *títan/titánic*; *télephòne/teléphonist*, etc., where restressing occurs). See Burzio (1994a) for detailed analyses (as well as note 16 below).

Once OO-F is thus introduced (and pending discussion of its exact domain of application), UR become not only superfluous, since one can think of morphology as a set of relations among surface forms (as in Bybee's (1988) et seq. 'Network' model) now regulated by OO-F, but one can specifically argue for its rejection. One such argument comes precisely from one of our main concerns, morphological 'irregularity', which can now be handled in the way illustrated in (17).

(17)

Input: */compUlS-ive/* Base: */compel/*		IO-F	OO-F
a.	compell-ive	*	
b. ☞	compuls-ive		*

The idea behind (17) is that the lexicon formed with Level 1 affixes, like *-ive*, is regulated by a relatively weak form of association between the derived word and its base, so that independent memorization of the derived word can also come to play a role. This is expressed by the ranking in (17), where IO-F (memorization) dominates OO-F. Under the ranking in (17), it is more important to be faithful to the input, taken for the moment to be the capitalized portions of *compUlS-ive*, than to the base *compel*, which would call for **compellive*. The output of this calculation *[kəmpɫlsɪv]* can then be taken to be the actually stored form, under the same principle of Lexicon Optimization which treated the output form *[əmérəkə]* as the actually stored form (no UR). As in the case of *[əmérəkə]*, the grammar, rather than mapping one representation into another, can then be taken to simply 'check' the form *[kəmpɫls-]* – putting aside the suffix *-ive* for now – by taking that whole form as the input, rather than just the capitalized portions in (17). The latter portions are merely the parts of the input that are 'active' in inducing violations of OO-F constraints under the ranking in (17), while the complementary portions of the input comply with OO-F. This is parallel to the fact that when the full form *[əmérəkə]* is taken as an input, some aspects of that representation are 'active' in inducing violation of various Markedness constraints (like the choice of particular segments, or the absence of an onset in the initial syllable), while other aspects comply with Markedness (e.g. the pattern of stress and of vowel reduction). The question remains, however, why the 'active' input in (17) is restrained in this fashion, concerning only some of the segments. I return to this question below.

The analysis in (17) addresses an important theoretical point about morphological irregularity. The present approach, a version of OT that trades in UR for surface relations under OO-F, reduces morphological irregularity to interaction of resources the theory independently has. In fact, it accounts for morphological irregularity in a way parallel to phonological markedness, also a form of 'irregularity'. As noted, in

OT, phonological markedness arises from IO-F prevailing over PHON-MARK constraints (the source of phonological regularity). Here, morphological irregularity arises from the same IO-F prevailing over OO-F (the source of *morphological* regularity). We can in fact think of OO-F as also spring-like, pulling the representation of the derived form *[kəmpʌls...]* towards a specific anchoring point in space, the representation of its base *[kəmpél]*. IO-F (=friction/memorization) is here sufficient to deflect that pull, just as it sometimes deflects the pull of the phonology. It has been a persistent challenge in generative work to capture the clear intuition that morphological irregularity taps into the same resources (memorization) as simple underived items, like *dog*. The present one is to my knowledge the first formal attempt to meet that challenge. By contrast, theories that have word-formation rules (yielding a UR) will require special machinery to list exceptions or readjust the output of the rules. There seems no reason for those exceptions or readjustments, however – the same theory without the special machinery would be simpler.

The reason the analysis in (17) excludes UR is that the latter is defined by the claim that allomorphy arises from a common input as illustrated in (15) above. In (17), however, the base *compel* and the stem *compuls* are from *different* inputs, which is why they differ. The reason they are partially similar is now OO-F, and no longer a common UR.

A second argument against UR is provided by the fact that Level 1-derived items are phonologically less marked than their bases, a phenomenon illustrated and analyzed in (18)–(19).

(18)

Input:	*/divíːn/*	IO-F	*V:	OO-F
a.	dívin	*		
b. ☞	diví:n		*	

(19)

Base:	*/divíːn/*	IO-F	*V:	OO-F
a.	diví:n-ity		*	
b. ☞	divín-ity			*

In (18b), the long vowel of *divine* violates a general markedness constraint,*V:, that bans long vowels. In languages that lack them, this constraint is dominant. In English, this constraint is evidently dominated by the relevant IO-F constraint, as in (18), whence the long vowel of *divi:ne*, and many other items. I assume, for reasons I return to, that OO-F is imposed asymmetrically, so that the 'base' *divi:ne* is insensitive to its derivative *divin-ity*, as indicated by the shaded cells in (18), while *divinity* is sensitive to its base *divi:ne*. Assuming further that there is no specific 'input' in *divinity* of the kind that was postulated for *compulsive* in (17), this form will

emerge faithful to *divine* except as mandated by the relevant phonology, indeed with a short vowel under the given ranking. Once again there is no simple account of this very pervasive phenomenon in a theory that has UR, since the latter entails that allomorphs, like *[dəváyn]* and *[dəvín]* must come from a common input (presumably with a long vowel), hence both subject to the same IO-F.

Note that the ability of a derivative to benefit from its own input (as in *compUlSive*) may seem to invalidate this account of shortening, however, since a form **divi:nity* could result from specifying a long *i:* in its input. In itself, this is not an incorrect result, since exceptions to shortening, like *obe:se/obe:sity* do exist, and can now be treated exactly in this fashion. An incorrect result would be to have 'lengthening' alternations, like hypothetical **blásph[ə]me/blasph[íy]mous* (instead of *blasph[íy]me/blásph[ə]mous*), which are not attested.[9] To rule out this case, I will take OO-F-length and *V:, when taken together, to outrank IO-F (while each is individually dominated by the latter). I will return to the summatory nature of such conjunctions. Hypothetical lengthening cases are thus excluded because they violate both constraints, while (attested) non-shortening cases violate only *V:, the long vowel being faithful to that of the base.

Vowel shortening receives on this approach the simple treatment in (18) despite the many different descriptive varieties, which had required separate treatment in rule-based work (*n[ey]ture/n[æ]tural; expl[ey]n/expl[ə]nation; res[ay]de/res[ə]dent; obl[ay]ge/obl[ɪ]gatory; r[iy]fute/r[e]futation; pl[iy]se/pl[e]sant; gener[ey]te/gener[ə]tive; articul[ey]te/articul[ə]tory*). As argued in Burzio (1993, 1994a, 2000a), all varieties reduce (under an appropriate theory of stress) to the three in (20), in which shortening is either highly regular or highly variable as indicated, for reasons traceable to the interaction of shortening (due to a PHON-MARK constraint) with preservation of the stress of the base (imposed by a constraint of the OO-F family).

(20)

	Shortening type	*Distribution*	*Preservation of base-stress*
a.	div[ay]ne/ div[ɪ]nity	regular	possible regardless of vowel length (no pressure against shortening)
b.	blasph[íy]me/ blásph[ə]mous cf.: des[áy]re/ des[áy]rous	variable	possible *only* with a long vowel (pressure against shortening)
c.	expl[ay]n/ expl[ə]nation	regular	*im*possible regardless of vowel length (no pressure against shortening)

The parenthesized portions in the right-hand column are the account for the different distributions in the middle column (see Burzio 1993, 1994a: Section 10.3).

[9] The lengthening of *canada/cana:dian*, and that of *mania/mani:acal* are regular and principled and do not fall into this category (see Burzio, 1994a).

In short, the notion of UR is imposed by a conception in which re-write/transformational rules are the formalism of choice to express regularities. For such rules, there must necessarily be different levels of representation. In particular, the input to a rule-based grammar is necessarily a representation that is stripped of all regularities, in contrast to a constraint-based grammar, where constraints can work in a 'checking' fashion. P&S's notion of 'Lexicon Optimization' in OT, which effectively dispenses with UR for morphologically underived items, can be straightforwardly extended to morphologically complex items, by assuming that such items are faithful, not to an 'input'/UR to which their bases are also faithful (IO-faithfulness), but rather directly to their bases – OO-faithfulness. Such notion of OO-faithfulness (OO-F) is not only logically possible in OT, but has been argued in various work (Benua, 1997; Burzio, 1994a; and others) to be necessary, making the role of UR in the characterization of allomorphy distinctly redundant. The above arguments based on (17) and (18)–(19) show in addition that the dismissal of UR is empirically necessary rather than just conceptually desirable. In particular, the notion of UR as a common input is falsified by morphological irregularity (*compel/compuls-ive*), which requires separate inputs for base and derivative. It is also falsified by phonological processes that apply only to derivatives and not to their bases, thus motivating two distinct notions of faithfulness: IO-F vs. OO-F.

On the present conception, the grammar is therefore a conglomerate of three components: IO-F; PHON-MARK; OO-F. These seem psychologically interpretable, respectively, as: some form of general memory; principles of sound structure partially determined by UG; and some form of associative memory.

A number of issues raised in this section will require further clarification, which I will attempt to provide later. One is that the above discussion seemed to still presuppose an independent morphological component, to the extent that it made reference to the notion of 'base'. Thus, morphologically derived forms like *divinity* were assumed to be faithful to their base, while base forms like *divine* were assumed to be calculated independently. The lingering question is thus: what defines the notion 'base of *w*', as the source of OO-F constraints relevant to the calculation of a word *w*? Another issue concerns the apparently 'restrained' character of the input in Level 1 formations. While there are cases like *antagon-ist*, where the full stem *antagon* has to be specified in the input (a 'bound' stem, since there is no word 'antagon'), in cases like *compuls-ive* there appears to be only a partial input, and in cases like *divini-ity* none. The question here is: if OO-F is totally dominated by IO-F in Level 1 derived items as in (17)–(19), why is it that OO-F is still substantially satisfied over these items, as if the input were in fact peculiarly 'restrained' – in fact, in apparent violation of the principle of the 'Richness of the Base' considered above. A third issue, related to the first two, is raised by the fact noted earlier that most irregularities are in fact *sub*-regularities. So, *comPULSIVE* is like *rePULSIVE*, *imPULSIVE*, etc., as well as like *comPULSIon, rePULSIon*, etc. These surface-to-surface similarities will also fall within the scope of the OO-F system as further developed below, revealing that the 'base', as a source of OO-F constraints need not be unique. The discussion of (17) above was thus oversimplified in that *compulsive*'s unfaithfulness to *compel* is attributable not only to IO-F, but also to the (secondary) OO-F to the *...PULS..* class at the same time.

4. Output–output faithfulness equals 'morphology'

4.1. Fatal attractions

The component of the present theory I have been referring to as OO-F holds the key to an understanding of 'morphology' and of the inverse correlation between morphological and phonological regularity stated in (1) above. As argued in Burzio (1994a, 2000a) and in part in Benua (1997), Level 1/Level 2 distinctions follow *en masse* from simple re-ranking of the associational component OO-F: low-ranked for Level 1, but high-ranked for Level 2. High-ranked OO-F will of course exhibit a (near-)inviolable character – the moral equivalent of a Pinker-style rule, but without its pitfalls, as we will see. This section attempts to characterize the workings of OO-F constraints by developing what is essentially a theory of analogical association. The resulting conception of the lexicon will be highly consistent with that of Bybee's (1988 et seq.) 'Network' model, while utilizing formal resources in the general vein of Optimality Theory.

I will argue that OO-F constraints result from the conflation of two effects. One is represented by the 'subcategorization' properties of each affix. Those properties can be interpreted as imposing a violable identity between the affix's stem and an item of a specific lexical category (essentially, the characterization of OO-F of Benua 1997). I turn to that property in the next section. In the present one, I discuss the second effect, described in (21).

(21) *Gradient Attraction*
   a. The overall structure of a word *w* (in both its phonological and semantic components) is influenced by that of other words in the lexicon to which *w* is independently similar, and which can be thought of as 'attractors' of *w*.
   b. The greater the degree of independent similarity, the greater the influence/attraction.

The effect in (21) can be illustrated with the following simple example. Formation of an *-able* adjective from the verb *compáre* yields two variants: *cómparable* and *compárable*. The point of note is that the latter variant is faithful to the verb both accentually and semantically, thus meaning 'able to be compared', while the former is both re-stressed and semantically unfaithful, meaning instead 'roughly equal' (Anderson, 1991: 193). The adjective *cómparable* is thus an instance of the semantic irregularity in Level 1 formations of (5c) above, which can now receive an account parallel to that of *morphological* irregularity in (17), namely: the deviant semantic traits are part of the 'input' for the derived word. Consider that an appropriate analysis of English word-stress would identify some pressure for the stress to be as in *cómparable*, (analogously to *ádmirable*) in violation of OO-F-stress; see Burzio (1994a: 285) for details. The question is then why such pressure prevails only when there is an independent semantic difference. Descriptively, OO-F-stress seems to require two different rankings, inconsistently: a lower rank for *cómparable*, and a higher one for *compárable*. But the observation about the semantics reduces

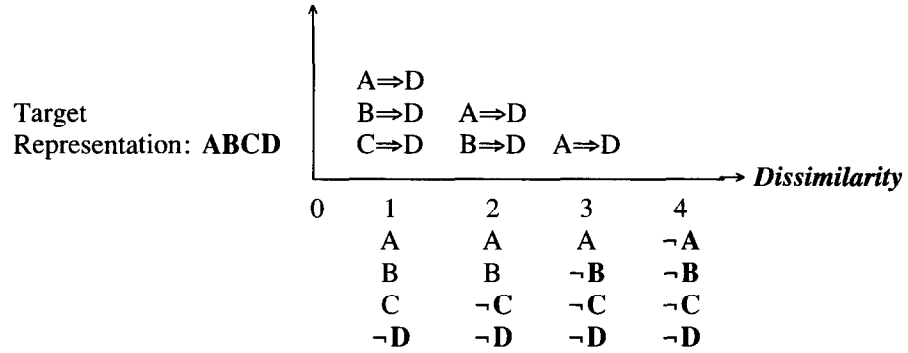
the inconsistency to Gradient Attraction (21): the greater semantic similarity induces greater phonological similarity, or – for that matter – vice-versa. The effect in (21) is amply attested, and relevant examples, in various languages, are collected in Burzio (1999). To mention just one additional case, Łubowicz (1998) notes that, in Polish, structures that have been differentiated from their bases by palatalization (k ⇒ č; ⇒ ǰ) will also undergo spirantization when the affricate is voiced (ǰ ⇒ ž), e.g. *dron[g]* 'pole'/ *dron[ž]*-ek 'little pole'. In contrast, items in which the voiced affricate is already present in the base, do not undergo spirantization (ǰ ⇒ *ž), e.g. *bry[ǰ]* 'bridge'/ *bry[ǰ] -ek* 'little bridge'. Hence the pressure for spirantization, like the pressure for a change in stress in the previous example, has an effect (i.e. prevails over OO-F) only if some independent difference between the base and the derivative has been introduced (here the palatalization).

The Gradient Attraction (GA) effect in (21) seems rather intractable by traditional generative formalisms, as it seems to involve a notion of *global* similarity, in which all representational dimensions interact with one-another and are implicated simultaneously. What does capture the effect in (21) is the assumption in (22), unorthodox for generative theory, but relatable to principles of neural computation. Such an assumption will also yield a new perspective on morphology as a whole.

(22) *Representational Entailments*
Mental representations of linguistic expressions constitute sets of entailments – a representation with the structure AB generating the entailments A⇒B, B⇒A.

On this assumption, representations which are similar but not identical will violate some of each other's entailments, whence an 'attraction' effect. The Representational Entailments (RE) assumption in (22) is a virtual re-statement of 'hebbian' learning, according to which: "When an axon of a cell A is near enough to excite cell B or repeatedly or persistently takes part in firing it, some growth or metabolic change takes place in both cells such that A's efficiency, as one of the cells firing B, is increased" (Hebb, 1949: 62). The co-firing of cells A and B is taken by Hebb to trigger a change that makes that co-firing necessary, just as co-occurrence of A and B is interpreted in (22) as being necessary. The simple illustration in (23) below reveals the general pattern of entailment violation produced by dissimilarity of two representations under (22).

(23) ***Entailments violated by '¬D'***



The diagram considers a four-component 'target' representation ABCD on the left, and lists above the horizontal axis the entailments violated by the presence of ¬D in another, 'candidate' representation, given below the horizontal axis. At point 1, where similarity between candidate and target is maximal, the number of entailments generated by the target but violated by the presence of ¬D in the candidate is 3, as listed at point 1 (e.g., the candidate violates 'A⇒D' because it has A but not D). As similarity is reduced by changing other components in the candidate, however, the 'pressure' against ¬D in terms of number of entailments violated is progressively reduced, until, at point 4, where the representations are totally dissimilar, there is no pressure at all. The *compárable/ cómparable* contrast now receives the analysis illustrated in (24), which will be extendable to the other instantiations of GA (21) noted in Burzio (1999).

(24)

	compáre	a. **compár**-able	b. **cómpar**-able
segmental structure:	A B	A B	A B
meaning: 'compare'	C	C	¬C
stress: *pá*	D	☜¬D***	☞¬D**

For the sake of illustration, (24) takes the structure of the verb *compare* to be a four-component vector, where the first two components, A, B are stand-ins for the segmental structure; the third, C for its semantics, and the fourth, D, for its stress pattern. In considering the adjective, I put aside the contribution of the affix *-able*, which would simply 'add' further components (both semantic and segmental) to the vector, and limit discussion to the components already present in the verb. Now, an adjective *comparable* will share those same segments: components A, B and, if it means 'able to be *compared*', also that semantics, namely C, as in column (24a). The question is: what happens to the stress at this point? Remember that the

phonology provides pressure to stress the first syllable, as in *cómparable* (= ¬D). That pressure is evidently stemmed here by the potential three-entailment violation, represented by the stars in (24a). Rather than incurring that violation, stress is faithful to that of the verb (= D). Matters are different, however, if the adjective has a different semantics (= ¬C), as in (24b). Now only a two-entailment violation stands in the way of re-stressing, not enough to oppose the phonology's demands, whence the restressing. One can of course apply the same reasoning in the other direction as well, and use identity of stress to block the semantic 'drift'. The general point is that differences or similarities over traditionally unrelated dimensions tend to cluster.

The RE assumption (22) thus provides a general framework for understanding word-to-word relations, by postulating a conversion (automatic, inherent in the character of mental representations) between representations and constraints (the entailments being types of constraints operative in the system). Words influence each other because they generate constraints which other words are then subject to. On the present conception, calculation of an individual word's structure presupposes taking the rest of the lexicon as a given, so that the lexicon is effectively a dynamical system of sorts. On this view, OO-F constraints therefore emanate from the lexicon at large, rather then from a unique morphological 'base'. Under GA, the largest contributions will come from those words that are independently the most similar to the candidate. However, we will see below that affixes have a way of privileging one specific target representation, thus re-introducing the traditional notion of 'base' in a qualified way.

The multiplicity of lexical relations is attested by cases where a unique morphological base would be insufficient. For instance, in Burzio (1998), I note that Italian agentive nouns like *vincitore* 'winner' can only be correctly calculated by simultaneous reference to both the participle *vinto* and the infinitive *vincere*, a situation I refer to as 'Multiple Correspondence'. This observation parallels others made for both English and French by Steriade (1997b, 1999), who refers to the phenomenon as 'Lexical Conservatism'. As she notes, for many French speakers, there are 'liaison' forms such as *[sot]*, as in the phrase *[sot] ami* 'silly friend-MASC', which requires simultaneous reference to both the canonical masculine: *[so]* (which provides the vowel), and the canonical feminine: *[sɔt]* (which provides the final consonant. Still similarly, I note in Burzio (1996) that the apparently idiosyncratic pattern of palatalization in Italian nominalizations, as in *comi[k]o/comi[č]ità* 'comical/comicalness' (with palatalization) versus *anti[k]o/anti[k]ità* 'ancient/ antiquity' (with no palatalization), nonetheless mirrors precisely the pattern of the adjective's plural: *comi[č]i*, versus *anti[k]i*. Thus, the abstract noun, which presumably does not specifically take the plural adjective as its only base (since it is not itself plural), is nonetheless sensitive to the plural, which must mean that it can be affected by any member of its general paradigm. What all these cases have in common (but see references for details) is a competition between OO-F to one form, which we may call the 'primary' base or attractor, like canonical masculine *[so]* or singular *comi[k]o* and the phonology that demands *un*faithfulness, respectively by requiring a linking consonant in *[soT] ami*, and by demanding palatalization in *comi[Č]ità*. The

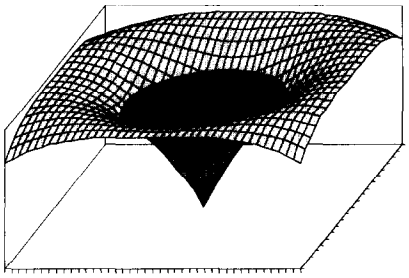
competition proves to be resolved in favor of the phonology only in the presence of a 'secondary' base or attractor, like feminine *[sɔt]* or plural *comi[č]i*, which assists the phonology's demands by kicking in its own OO-F/ attraction (Steriade's 'lexical conservatism'). Summation of effects is thus essential to the present approach: not only must entailments be able to sum up in the determination of the most harmonic state (a violation of three being worse than a violation of two in (24)), but entailments from association (OO-F) must be able to sum up with effects from the phonology. This brings up a point of theoretical clarification.

Most work in OT follows Prince and Smolensky (1993) in taking constraints to be 'strictly-ranked', in the sense that lower-ranked constraints cannot – by joining forces – prevail over higher-ranked ones. We have just seen cases, however, where that is not true, and a good number of others are known. Smolensky (1997) proposes in this connection that constraints can, under special circumstances, indeed form 'conjunctions' of higher rank than each of the conjuncts. In the present work, I will proceed from the opposite direction, and assume (as in fact in Burzio, 1994a) that constraints are inherently summatory, i.e. that they have numerical weights, as in fact in the 'Harmony Theory' of Smolensky (1986). Other work also assumes numerically weighted constraints, e.g. Flemming (1995), Boersma (1998). To the extent that 'strict ranking' effects exist (i.e. that summation effects are still somewhat rarely observed), I propose that *they*, rather than the summation effects should be theoretically derived. That is, I take the position that 'strict-ranking' has the status of a (quasi-)generalization in need of an explanation, rather than that of a theoretical primitive. The RE hypothesis in (22) has in fact the potential for deriving it. Since it makes constraints not distinguishable from the representations that satisfy them, a constraint that, for any reason, tends to prevail, will then succeed in recruiting large numbers of representations through the lexicon, which will in turn reinforce it by means of their representational entailments. This 'strengthening-of-the-strong' effect will work to create substantial differences in weight among conflicting constraints (in fact proportional to the domain of conflict), thus approximating the effect of strict ranking.

Another respect in which the present view may appear unorthodox compared with other work in OT is that it does not maintain that all constraints are universal (with only the ranking being language-specific). Obviously, since representations are not universal (e.g., the word *dog*), the entailments that they generate under (22) will also not be. PHON-MARK constraints could still be regarded as universal in the present context, except that their effects and those of RE/OO-F (not universal) may not always be clearly separable, as noted in the discussion of (6) above.

Earlier in the discussion, I compared the effects of OO-F to those of phonological markedness, and in turn to those of a spring. That comparison needs revising in light of GA. The pull of a spring lessens as the target is approached, and this is correct for markedness (IO-F = friction will prevail once the pull has lessened sufficiently). However, the linear function illustrated in (23) shows that, as identity to a target representation is approached, the pressure against the residual differences increases instead. We may find a proper mechanical analog to OO-F/ GA effects in the variably sloping walls of a hole, as in (25).

(25) **Gradient Attraction effect**



A representation being calculated under GA, like *compar* in *compar-able* can be thought of as an object being pushed by gravity to the center of the hole in (25), a point which is in fact another representation (the 'attractor'), here *compáre*. The closer the candidate representation gets to it, the steeper the slope, and thus the stronger the push. Both IO-F (friction) and PHON-MARK (spring) can in principle stop the object on the slope, but they stand a better chance on the flatter than on the steeper part. The linear function in (23) is the derivative of the sloping function in (25) (it is maximal near the center/ identity to the target). The present conception is therefore that one fundamental property of lexical representation is their inherent tendency to collapse into each other, or 'neutralize' – the closer they are, the stronger the tendency. They do so, however, in a medium that lacks fluidity (i.e. has built-in friction = memory), while also being simultaneously swayed by PHON-MARK.[10]

4.2. Of morphemes and word-formation rules

One can view the sub-theory that we call 'morphology' as essentially describing patterns of neutralization, since it aims to account for the fact that words do not differ from each other randomly, but rather only by highly consistent clumps, called 'morphemes'. Allomorphy, a violation of OO-F, is failure of complete neutralization, for which there are only two causes in the present system as noted: IO-F (= word-specific memorization) as in *compel/compuls-*, and PHON-MARK, as in *divi:ne/divin-* or *beep-[t]/bribe-[d]*. Calculation of each allomorph is based here on all of the others, which act as 'attractors' or holes like (25), which are partially intersecting given their proximity. Since the notion of 'morpheme' defines a type of invariance in multidimensional space, it can be captured by RE (22): given a certain

[10] One can in fact think of excessive proximity to another representation as a special type of markedness. This is exactly the view introduced by the 'dispersion theory' of Flemming (1995) relative to segmental inventories. For instance, English unstressed vowels, because of their low level of articulatory energy, are perceptually too similar to each other, and thus neutralize into the single vowel *[ə]*. Steriade (1994, 1997a) and Wilson (2000) extend the application of dispersion principles from segmental inventories to patterns of segmental neutralization. The text further extends their application to morphology. See Burzio (2000b) for more explicit discussion of this extension and its consequences.

association of sound and meaning in some representation, other representations will be conditioned to maintain the same association under RE.

Traditional word-formation rules also express a form of invariance. Their effect can also be captured under the RE hypothesis, as illustrated in (26).

(26)

Lexical item	Entailments	
	I	II
a. parental	*al* ⇒/*parent*___	*al* ⇒/N ___
b. natural	*al* ⇒/*nature*___	*al* ⇒/N ___
...	...	...
c. Entailments summation over the lexicon: $\sum_{i=1}^{n}$	??	> 2
d. 'Macro'-entailments (constraints)	___	*al* ⇒/N ___

The representation of a word like *parental* (26a) will generate a certain number of entailments that depends on the number of dimensions in the representational space it implicates. Among these entailments there will be some whose effect can be abbreviated as in column (I), read: 'if there is a structure 'al' (including its semantic structure, with adjectival meaning, etc.), there must be a structure 'parent' preceding it. There will also be some entailments that can be abbreviated as in column (II), read: 'if there is a structure 'al', there must be a noun preceding it'. This second set of entailments is a subset of the first, in that the property 'noun' is part of the representation of 'parent'.[11] The same holds for other *-al* adjectives, like *natural* of (26b). Now the entailments in column (I) are largely contradictory, while those in column (II) are consistent with one-another. In the calculation of each word with *-al*, there will thus be a scant effect from column (I), where summation yields noise, but a significant one from column (II), where summation yields essentially the subcategorization frame for the affix, roughly equivalent to a Word-formation Rule (WFR), except in the form of a violable constraint.[12] We may refer to such entailment summations as 'Macro'-entailments. Subcategorization frame-like macro-entailments

[11] More accurately, the representation *parént*, part of *paréntal* carries an association with (i.e. entails) the property 'noun', by virtue of its association (i.e. shared entailments) with the word *párent*, whose semantic property it is to be a 'noun'.

[12] Note that combining morphemes thus causes disharmony (contradicted entailments, as in column (26I)). A similar kind of disharmony occurs with any combination, including combination of segments. I assume that such disharmonies are nonetheless optimal, since the alternative, consisting of having words which are only monomorphemic, or – for that matter – monophonemic, will cause a worse overpopulation of the relevant space. It is clear that combinations use a higher-dimensional space because they add time – a dimension with an infinite number of values, to the other dimensions.

such as (26d) will be the second contributor to OO-F, along with Gradient Attraction, effectively enhancing the latter attraction, as further discussed below.

The Representational Entailments hypothesis (22) thus enables us to derive both notions of 'morpheme' and of WFR, formerly primitive. In their new form, these are both violable constraints, because the primitive notion on which they are based, that of 'entailment' – an atomic form of mental association, is itself violable.

The present conception mirrors that of Bybee's (1988, et seq.) closely. On Bybee's view, similar words generate connections whose strength reflects the degree of similarity. On the present approach, strength of connections is a metaphor for the number of shared (i.e. mutually satisfied) entailments. In Bybee's system, parallel connections (*parental* to *parent; natural* to *nature*; etc.) form a 'schema', here a macro-entailment like the one in (26d). A schema can be weak or strong, and that would correspond to the ultimate rank of the macro-entailment, coming from summation across the lexicon. The important issue of frequency that Bybee's work has addressed can also be brought within the scope of the present framework. Bybee notes that item-specific idiosyncrasy requires high token frequency, and that the strength of a 'schema' also depends, not only on the number of instantiations through the lexicon, but on the frequency of instantiation in use (type-frequency). This effect can be captured by assuming that entailment summation occurs not only over the lexicon in the manner illustrated in (26), but also, more generally, over experience. Individual representations that are experienced more frequently build up stronger entailments, making those representations less susceptible to the regularizing effects of OO-F. Similarly, a schema that is instantiated more frequently (high 'type' frequency) will build up stronger macro-entailments, resulting in a stronger OO-F/ regularizing effect. In Bybee's conception, a schema can also be relatively open or closed. Here, that notion would correspond to the amount of contextual information that survives from column (26I) into column (26II). The schema for the regular past-tense is relatively open because the diversity of verbs occurring with it reduce the characterization of its context to noise except for the specification 'verb', as in (27a) below (where – again – I abstract away from the [-t/ -d/ -ɪd] allomorphy). On the other hand, the schema for the past-tense of *sink, ring, sing, cling* is relatively closed because more contextual information emerges from the set of cases in which it occurs, as in (27b).[13]

(27) a. ed ⇒ /]$_V$ ___
'past-tense'

b. [æ] ⇒ / [C_0___ŋ]$_V$
'past-tense'

Irregular past-tenses violate the association of the meaning 'past-tense' with the structure *-ed* of (27a) (the entailment 'past-tense'⇒ *-ed*). The reason is that more specific information such as that in (27b) has a way to take precedence over more

[13] I provisionally ignore *swim* and *begin*, missed by (27b).

general information such as (27a) despite the 'strength' of that schema. In the present framework, this is made possible by the richer entailment structure, detectable when (27a,b) are re-stated as (28I, II), respectively.

(28) I. a. ed
b. 'past-tense of verb'
II. a′. [æ]
b′. 'past-tense of verb'
c′. $[C_0\_\_\_(k)]_V$

(28I) indicates that the form *-ed* conveys the meaning 'past-tense of verb', and the same is true of the form *[æ]* in (28II). In addition, however, *[æ]* also entails, and is entailed by, the specific form of the verb in (IIc′). A past-tense *[ræŋ]* thus violates the entailments $b \Rightarrow a$ from (I), but the alternative *[rɪŋ]-ed* violates the entailments $b' \Rightarrow a'$ and $c' \Rightarrow a'$ from (II) – a larger number of entailments, especially since c' is a complex representation, making $c' \Rightarrow a'$ shorthand for a set of entailments. Hence closed schemas have some advantage over open ones, apparently sufficient to offset the greater 'strength' of the schema in (28I) in this case. We must note, however, that – in point of fact – nonce forms like *[frɪŋ]* do not always elicit past-tenses like *[fræŋ]*, but – as the psycholinguistics literature shows – may rather yield regular *[frɪŋ] -ed*. This is because the characterization in (27)–(28) is oversimplified, the schema in (28II) being even more 'closed' than indicated. Because the set of items like *[ræŋ]* is rather small (10 items: Pinker and Prince, 1988: 187), what emerges is more like a list of such items than a true generalization like the one in (28c′), witness also the fact that *swim* and *begin*, also umlauting to *[æ]*, violate that generalization. Any new item will then violate the list, though only partially, if it shares entailments with members of the list.

Note here that the irregularity of *rang* just discussed is slightly different from that of *compulsive* discussed earlier. The former violates the entailment 'past-tense ⇒ *-ed*' generated by all the regular past-tenses – a general GA effect. In contrast, the latter violates not only the general attraction generated by *compel*, but also the specific entailment '*-ive* ⇒ / V__' due to the affix (*rang* does not have the regular affix). Hence, they both violate OO-F, but in different ways , only the latter violating the component of OO-F which is contributed by the affix. There is no past-tense **compuls-ed* parallel to *compuls-ive*, because, if *-ed* is selected, the entailment generated by *-ed* is stronger than that generated by *-ive*, resulting in (Level 2) higher ranked OO-F. Still, both types of irregularity, *rang* and *compulsive*, are accounted for similarly in terms of IO-F prevailing over OO-F. There is a specific 'input' to *rang* which prevents it from turning into **ring-ed*, just as there was a specific input to *compuls-ive* which prevented it from turning into **compell-ive*. The discussion of (28II) above, however, has now effectively reduced the notion of IO-F to the more primitive notion of representational entailment – the same basis as OO-F. When item-specific memorization (IO-F) prevails over general regularity (OO-F), as in both *rang* and *compuls-ive*, it is because item-specificity is higher-dimensional, as in (28II), yielding a richer entailment structure, while generality – as in (28I) – is

lower-dimensional by definition. Under this unification, a listed form which makes exception to a generalization can itself be seen as an 'attractor', which evacuates a region of space around it. For instance, any candidate representation in the space defined by 'past-tense of verb "ring" (and associated meaning)' will necessarily be proximate to, and hence tend to collapse with, the listed form *[ræŋ]* rather than satisfy the macro-entailment *past-tense of V* ⇒ *V-ed*. The structure *V-ed* will also be an attractor, but a weaker one. While the high type frequency of *V-ed* boosts its attraction, the high token frequency of *rang* will boost the latter's attraction in turn, making irregularity possible. Unification, under the primitive notion of 'entailment' notwithstanding, I will continue to refer to IO-F and OO-F as distinct categories. The above phenomenon, where a listed form is chosen over one that could be calculated instead is referred to as 'morphological blocking'.[14] The often-noted fact that 'blocking' ceases and regularization occurs with denominal verbs, like *ring/ringed* 'construct a ring around' follows here from the fact that such verb, by being most directly related to the noun, is effectively in a different region of space (away from the listed attractor *rang*).

In sum, words are associated with each other by means of their *surface* rather than some 'underlying' representation. In addition, they do so in the way described by Gradient Attraction (21). This requires implementation of some notion of attraction that is inversely proportional to distance in multidimensional space. That notion is derivable from the 'Representational Entailments' hypothesis in (22) about the nature of mental representations, which is essentially a principle of neural computation. On that hypothesis, identity over some dimensions translates into pressure for identity over others. The larger the number of dimensions that satisfy identity, the greater the pressure (number of entailments generated) on those that violate identity. This conception can recapitulate both staples of traditional morphological machinery, the notions of 'morpheme' and that of 'word-formation-rule', which are now rendered as types of violable constraints. Individual representations are higher-dimensional vectors than lexical generalizations. This enables some representations – those that are instantiated with sufficient frequency – to escape those generalizations. In contrast to the violable character of the entailment-based generalizations of the present system, traditional, 'symbolic' type word-formation rules are inviolable. We will see below that this property dooms them to failure by preventing them from correctly interacting with the rest of the system, specifically phonology.

Note as a final clarification that the present claim based on Gradient Attraction (21) is only that all dimensions (phonological, semantic, etc.) are capable of interacting with one-another, as supported by the evidence. No specific claim is made as to what the relevant dimensions are, or their relative weights. That part of the inquiry remains relatively orthogonal to the present discussion, which concerns questions of general architecture.

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[14] This account of morphological blocking is – not surprisingly – similar to the one provided by connectionist approaches (Daugherty and Seidenberg 1994: 385f.). It is also similar to aspects of the account in Hayes (2000). Specifically, the above expresses Hayes' 'Minimal Generality Principle' according to which a WFR is assumed to be maximally specific first, and is generalized only when specificity is contradicted by the evidence.

5. Loose ends tied

At the end of Section 3, a number of issues were left open that can now be addressed. One was the base-derivative asymmetry. In general, 'bases' seem able to influence their derivatives, as in (16) above (*américan/américan-ist*, etc.), while the opposite seems to occur much more rarely, and was assumed not to occur in the simplified discussion of (18) above. Consider for instance that the stress of *paréntal* does not result in **parént*, despite the acceptability of that same stress pattern in *cemént*. The informal notion of 'similarity' utilized in the statement of Gradient Attraction (21) does not provide for the needed asymmetry, but the notion of 'attraction' does, once it is based on the entailment-violation function of (22)–(23). The reason is as follows. A base form like *parent* necessarily violates some of the entailments generated by *parent-al*, in particular, those abbreviated by *parent* ⇒ /__ *al* ('the structure *parent* entails a following *al*'). For this reason, *parental* is a relatively weak attractor for *parent*. In the 'hole' (25) that has *parent-al* at its center, *parent* sits some way up the slope. In contrast, by virtue of being a superstructure of *parent*, *parent-al* has the inherent ability to satisfy all of the entailments of *parent*, and is thus subject to strong attraction (steeper part of the slope). Hence an affix form is correctly predicted to have a relatively weak effect on the calculation of its 'base', while the latter will have a relatively strong effect on the calculation of the former.

Another issue that was left open was the one I referred to as 'restrained input'. For Level 1 formations, I assumed the ranking of (17)–(19) 'IO-F >> OO-F'. This ranking was necessary to allow for morphological irregularity, but then required an 'input' to be absent in all the morphologically regular cases (*parent-al*; *divin-ity*; ...). This is an apparent violation of the 'Richness of the Base' principle. The introduction of RE (22) sheds some light on this effect as well, in that it yields OO-F constraints that are variable in rank, depending on closeness to target. This makes it possible to slightly reinterpret the earlier ranking. The 'Richness of the Base' requires taking the input (= the Base) to be free of all properties, properties of the output always demanding an account in terms of the grammar. But consider as well that not all inputs are instantiated. For instance, the word *splot*, presumably possible in English, does not exist. This means that the input has no properties in the sense that it is randomly distributed, hence randomly missing in some cases. From this point of view, the effects of the input seem merely more thinly distributed across the Level 1 lexicon than across underived items (a limited amount of input for *rabbiN-ic*, *problemAT-ic*, *compUlS-ive*, etc.; perhaps none for *napoleon-ic*, *dismiss-ive*, etc.). But we know that the space of derived items has different properties than the general space – it is populated by stronger attractors. So, the presence of *-ive* will contribute to the pressure for any structure that precedes *-ive* to neutralize with that of an existing verb. This pressure enhances the GA effect due any similarity, although the overall effect is presumed to still be inversely proportional to distance. This means that the formerly categorial ranking 'IO-F >> OO-F' needs reinterpreting as holding only from some point of the slope in (25) on up, while near the origin/center of the hole the inverse ranking holds. In fact, since the curve's derivative is likely very large near the origin, there is a virtual guarantee that such inverse ranking will hold for

some non-null region right around the attractor/hole. This correctly predicts that, under those conditions, effects of the 'input' (morphological irregularity) will be present, but somewhat more dispersed. I acknowledge the further prediction that this makes that differences between an affixed stem and the independent word *(compUlS/compEl)* would tend to be significant, so as to reduce the pressure for neutralization. I am not able to assess the correctness of that prediction at the moment, except to note that the high incidence of 'bound' stems (stems for which no independent word exists) is consistent with it. In the present context, we will be content to note that indeed there are plausible reasons to expect that the effects of the input (=memorization) should be more scattered in Level 1 affixed items than in unaffixed ones, due to the fact that affixes serve as attraction enhancers.[15]

The next and last point also supports the view that IO-F does not totally dominate OO-F in Level 1 formations. I noted above that morphological 'irregularities' often form subregularities, as in *personiflCATION* ≈ *applICATION* ≈ *publICATION, etc.* (like regular *dedICATION*); *problemATIC, dogmATIC*,etc (like regular *acrobATIC*); or, for that matter, *ANTAGONist* ≈ *ANTAGONism* ≈ *ANTAGONize*, where *antagon* is a 'bound' stem (not an independent word). What this means is that, when IO-F appears to prevail over OO-F, it is typically assisted by a secondary form of OO-F (to the other words sharing the 'irregularity'). This effect is parallel to the 'secondary base' effects noted above, e.g French *[soT] ami*, whose linking consonant comes from the feminine *[sɔt]*. In both cases, deviation from one pattern occurs by conforming with another pattern – the 'lexical conservatism' of Steriade (1997b, 1999). The difference is that, in the earlier 'secondary base' cases, PHON-MARK (syllables must have onsets) is the co-conspirator with the secondary base/pattern, whereas, here, IO-F is (input being needed to channel, e.g., *'expect...ion'* into the *ation* pattern, eschewing **expection*, like *correction*). But we have also seen that PHON-MARK is in fact also partly involved in many cases of morphological 'irregularity', like *rabbiNic, dogmaTic*, etc., where the inserted consonant also provides an onset. The entailment summation approach taken here makes it possible to capture this action-in-concert effect.

In sum, Level 1 affixes impose on their stems a relatively weak form of association with an independent word. That requirement is part of the OO-F system of constraints based on the Representational Entailments hypothesis in (22) about mental representations. Because the requirement is weak, it can be overridden by the other two types of constraints in the system: IO-F, yielding morphological irregularity, and PHON-MARK, yielding phonologically motivated alternations. However, because strength of association is not a fixed number but a sloping function as in (25) above, the OO-F imposed by Level 1 affixes is only generally rather than categorically weak. This accounts for the fact that IO-F effects (morphological irregularity) are relatively restrained, and typically result in a pattern of subregularity (secondary OO-F effect) or in structures independently favored by PHON-MARK.

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[15] This supersedes the account of the 'restrained input' effect in Burzio (1997), based on the assumption that violations of OO-F add up over the stems selected by an individual affix, such that, when the number of violations is sufficiently large, OO-F will overcome IO-F.

It should be clear by now that, in contrast to Level 1, the Level 2 lexicon simply involves high-ranking OO-F, and that all observed differences between these two sectors of the English lexicon stand to follow from that more primitive one.

6. The morphology–phonology competition

The inverse correlation between morphological and phonological regularity stated in (1) above follows on the present theory from the fact that 'morphology' is a set of identity-imposing associations. When such associations are strong, morphology looks 'regular'. Phonology, on the other hand, can force violations of such associations, but it will succeed only when the latter are weak. In the latter case, however, effects from the third component of the system, IO-F, expressing the role of word-specific memorization, will also automatically crop up, yielding idiosyncratic violations of morphology. Hence phonology will appear to apply 'regularly' only when morphology will often look 'irregular'. I return below to the factors that may control the strength of the associational component – OO-F, over different affixal classes. First I review the differences between Level 1 and Level 2 lexicon and show how they all follow unitarily from the assumption that OO-F constraints, which (aside from the qualifications of the previous section concerning the less-than-categorical nature of the ranking) are ranked for Level 1 as in (29a), but for Level 2 as in (29b).

(29) a. Level 1 lexicon: IO-F >> OO-F
b. Level 2 lexicon: OO-F >> IO-F

Recall that, since Level 1/ Level 2 lexicons are defined by classes of affixes, what OO-F in (29) refers to is the identity between a stem that a specific affix takes and some independent word, as in the subcategorization frame-like statements in (30).

(30) a. -less ⇒ / Noun ___
b. -ed ⇒ / Verb___

Two related questions arise here. One is why affixes tend to be unambiguous in the ranking of the OO-F they impose on their stems: either as in (29a) or as in (29b). The other is why, in doing so, they are consistent across dimensions. One might have imagined a situation in which a conditional like (30a) would impose *segmental* identity to an existing noun with one rank, but *accentual* identity with some other, perhaps lower, rank. This does not happen, however. Hence (29a,b) refer to all dimensions simultaneously (pace note 16). As we see below, the answers to both questions lie in the interaction across dimensions due to the RE hypothesis in (22).

The ranking in (29b) correctly predicts that all the Level 1 characteristics in (31), which repeats (5) above, will disappear at Level 2.

(31) *Level 1 Morphology*

a.	Morphological irregularity:	compUlS-ive, personifiC-ation, problemAT-ic, ...
b.	Bound stems:	STUPEND-ous, ELECTR-ic, INEVIT-able, ..
c.	Semantic irregularity:	*regrett-able*: 'that **can* be regretted'; *electric- ity*: *the condition of being electric'; ...
d.	Low productivity:	*student-al, *tavern-ous, *suspend-age, ...

Each of (31a,b,c) result from faithfulness to an input that the derived form has, independent of its 'base'. The Level 2 ranking in (29b), however, privileges faithfulness to the base. Hence, in contrast to the calculation of irregular *compuls-ive* in (17) above, calculation of regular *compell-ed* proceeds as in (32), which assumes hypothetical */compuls/* in the input.

(32)

Input: */compUlS-ed/* Base: */compel/*	OO-F	IO-F
a. ☞ compell-ed		*
b. compuls-ed	*	

The input *compuls* has here no effect. Similarly for any other input, thus accounting for each of (31a,b,c). The point in (31d) will receive a similar account, as we see next.

I reasoned earlier that affixes act as 'attraction enhancers'. So, if we take any noun in the lexicon, it will generate a field of attraction, or a hole like (25) above, the noun being in the center. A representation occurring in the context: ___*-less*, however, will be subject not only to that general attraction, but also to the entailment in (30a) due to the affix, that demands that the stem be a noun. The affix will thus have the effect of enhancing the attraction of each of the nouns in the lexicon, the walls of the hole in (25) effectively having been made steeper, for each noun. One can imagine that, where the effect of the affix is of a large-enough magnitude, there may not be any point in space where IO-F ('friction') could prevent a candidate representation from collapsing into an existing noun. This seems applicable to Level 2 formations, where a hypothetical representation *arbore* in the context: ___*-less*, which would give **arbore-less* 'without trees' seems forced – given its semantic proximity – to collapse into the existing *'tree'*, giving *tree-less* instead, the paucity of bound stems: *reck-less*, *hap-less*, revealing that indeed there is very limited opportunity for them here. In contrast, where the effect of the affix is of a lesser magnitude, there would be good opportunity for IO-F to overcome the corresponding attraction, as seems to be the case for Level 1 affixes. This would be why a corresponding *arbore-al* 'pertaining to trees' is possible, with *arbore* a memorized point

on the slope. This representation fails to collapse into *tree* and thus give **tree-al* (or *treeTal/ treeMATal*, etc.) despite the semantic affinity with *tree*.

This now helps us understand (31d) above and the issue of productivity. If semantic affinity is not sufficient to guarantee stem-to-word neutralization with Level 1 affixes, then an input representation featuring only the semantics of *student* in the context ___*-al* may be insufficient to guarantee collapse with the noun *student*, and thus insufficient to yield **student-al*, rather leaving the representation without an associated sound structure. Under the stronger attraction induced by Level 2 affixes, however, the same type of input will straightforwardly yield, for instance, *student-less*. Existing Level 1 formations must therefore be 'primed' by a sufficient input. For instance, the word *parent-al* must benefit from a sufficient amount of input specific to that word (not just the input for *parent*) including some specification of its sound structure, to place its stem within reach of *parent*. What that input is, exactly, will be indeterminate, since the relevant notion of distance is multidimensional, and proximity along different dimensions can be equivalent. This revises our earlier assumption that Level 1 regulars like *parental*, etc. had no input and were simply generated by OO-F. The revised assumption is that regulars require *less* input (since OO-F can fill in) than irregulars. Earlier conclusions will stand. The new conclusion is that all Level 1 formations are partially memorized.

From this point of view, absence of bound stems (or other irregularity), and productivity, are essentially the same phenomenon, and result from the fact that any minimal input representation in a regime of strong attraction will necessarily collapse with one of the independently existing items, always successfully yielding a 'word-affix' combination, aside from some effects of the phonology, to which I now turn.

The table in (33) summarizes relevant phonological alternations, repeating some of (6)–(7) above. The shaded area highlights missing alternations.

(33)

		Level 1	Level 2
a.	Vowel shortening	natur-al, ...	**deli:ght-ful**
b.	Velar softening	authenti[s]-ity, ...	**traffick-ing**
c.	Re-stressing	parént-al, ...	**méaning-ful, éffort-less...**
d.	'Base (only)-neutralization'	condem[n]/ condem[n]-ation, ...	**condem[n]-ing, ...**
e.	De-syllabification	cent[ɾ]/ centr-al, ... cyc[l̩]/ cycl-ic; ...	**cent[ɾ]-ing, ...** (cyc[l]-ing); ...
f.	Flapping (Am. English)	anecdo[ɾ]-al, ...	permi[ɾ]-ed, ...

Consider that what the ranking in (29b) above predicts is that Level 2 items should be at least as phonologically marked as morphologically simple/'underived' ones, and typically more so. The reason is as follows. In simple items, markedness is due to domination of some PHON-MARK$_i$ by IO-F, as in (34).

(34) Underived items: (PHON-MARK$_j$ >>) IO-F >> PHON-MARK$_i$

Absence of markedness, on the other hand, is due to the opposite ranking – the one holding for PHON-MARK$_j$ in (34). Now the Level 2 ranking in (29b) will guarantee (given transitivity of ranking) that any PHON-MARK$_i$ dominated in (34) will continue to be dominated in the Level 2 grammar, since the latter rests on higher-ranked OO-F. On the other hand, there may well be some PHON-MARK$_j$ undominated in (34) now dominated, as in (35).

(35) Level 2 items: OO-F >> (PHON-MARK$_j$ >>) PHON-MARK$_i$

Hence the Level 2 markedness will be equal to or greater than that of morphologically underived items. This effect is the one visible in (33c,e). Underived items do not instantiate the stress pattern of *méa.ning.ful*, *éf.fort.less*, etc. Compare: **á.gen.da*; **ím.por.tant*, etc. Nor do they allow syllabic sonorants word-medially as in *cent[r]-ing*, etc. Compare **cathed[r]al*, etc. I have already noted the syllabification facts as well: there is no underived item with the syllabification of *beeped* (long V followed by cluster; only, e.g., *abrupt*, with a short vowel).

Level 1 items, on the other hand, should turn out at least as *un*marked as underived ones and typically more unmarked under the ranking in (29a), which gives (36) by transitivity from (34) .

(36) Level 1 items: PHON-MARK$_j$ >> (PHON-MARK$_i$>>) OO-F

That is, any PHON-MARK$_j$ undominated in (34) should remain undominated when the Level 1, lower- ranked OO-F is involved, as in (36). At the same time, there may be a PHON-MARK$_i$ dominated in (34) now undominated. Both effects in (33a,b) are of this type.[16] Both vowel shortening and velar softening obtain only in Level 1 derived items, and 'block' over underived ones, witness *cri:me*, *di:nosaur*, *ni:ghtingale*, etc; and *king*, *kick*, *leukemia*, etc. Any effects of this sort (blocked in underived environments) is guaranteed to disappear at Level 2 (where PHON-MARK$_i$) is dominated, indeed as indicated in (33).

The alternation in (33d) is also guaranteed to disappear at Level 2. The reason is that the *n* of *condem[N]-ation* is on the present analysis part of the input for that word. That input is effective in causing a discrepancy with the base *[condem]*, similarly to the case of *compel/ compUlS-ive* in (17) above. In the Level 2 formations, however, a hypothetical input */condemN-iŋ/* will be leveled to *[condem-iŋ]* by the

[16] Stress seems to be an exception to this. As we saw with regard to (16) above, the stress pattern of some Level 1 items is more marked than that of underived items, suggesting that OO-F for stress holds a specially high rank. This would in fact be consistent with Gradient Attraction (21). In the cases in which we observe stress identity, there is independent identity of segmental structure. The effect of segmental identity on stress identity can be verified in various cases, for example in: *eléct/eléctable vs. éligible; lárynx/lárynxes vs. larýnges*. Indeed, when segments change, but only then, stress is free to change as well.

dominance of OO-F, similarly to */compUlS-ed/* being leveled to *[compell-ed]* as in (32) above. The alternation of *[condem]/[condemN]-ation* is only partially similar to that of *[compel]/[compUlS]-ive*, though, which is why it is classified here among the phonological ones. The reason is as follows. Although pressure for leveling is asymmetrical, with a 'base' more strongly pressuring its derivatives than the other way around as discussed earlier (Section 5), the present system predicts that there should also be pressure in the other direction, though less, whence the facts that 'backward copying' is only more rarely attested rather than non-existent. In this connection, see Burzio (1994a, b) for arguments that the stresses of, e.g., *académic*, *pervért* are back-copied from *académic- al*, *pervért-ing*, respectively. On this view, the form *[condemN]-ation* will entail the form **[condemN]* for the verb. Such form is precluded by the phonology, however, that prohibits final clusters **mn*. In the case of *[compel]*, the corresponding entailment from *compuls-ive* that it be *[compUlS]* is blocked only by its own input */compel/*. Hence, the alternation *[compel]/[compUlS]-ive* is totally input driven (= morphological irregularity), while *[condem]/[condemN]-ation* is partly phonologically driven.

One type of variation that is *not* guaranteed to disappear with Level 2 items is the 'allophonic' type of variation, like that of (33e, f). Allophonic variation is that which is contextually predictable and hence non-contrastive. The [t/ɾ] variation of (33f) is allophonic in (American) English because no contrast employs it. There are no pairs like *[æɾəm/ ǽtəm]* or *[atémpt/ aɾémpt]*, but only *[æɾə́m]* (*atom*, or *adam*), *[atémpt]*, showing that the [t/ɾ] variation is contextually driven. In OT, allophonic variation is characterized by the ranking schema in (37) (Burzio, 2000a; Kirchner, 1997).

(37) Allophonic variation: $\text{PHON-MARK}_{\text{CONTEXT}}$ >> $\text{PHON-MARK}_{\text{GENERAL}}$ >> IO-F

In its application to flapping, the 'general' constraint in (37) would be one that bans flaps altogether, while the contextual one favors them in a specific environment (between a stressed vowel and another vowel). Similarly for the syllabic sonorants in (33e): banned generally, but favored word-finally. Here there is only a possibility rather than a guarantee that the OO-F of Level 2 items (which needs to dominate only IO-F) will come to dominate one or both of the markedness constraints, and hence suppress allophonic variation. The data in the shaded part of (33e) reveal that Level 2 OO-F dominates the general markedness constraint, thus yielding syllabic sonorants non-finally. The (dialectal) data in the non-shaded portion, however, reveal that the opposite ranking, with OO-F dominated by the general constraint in (37) can also obtain. Similarly, the regular application of flapping in (33f) reveals domination of OO-F by the contextual constraint in (37). The third logical possibility, with Level 2 OO-F dominating both of the markedness constraints in (37) is identified in Benua (1997: Section 5.3.1), based on Borowsky (1993), as the case of 'Belfast dentalization'. In the Belfast dialect, *spider* is pronounced with a dental *d* by assimilation to the *r*, but *rid-er* is pronounced with an alveolar *d* just as in *ride*. Here OO-F causes violations of the contextual markedness constraint of (37), thus transferring the unmarked allophone into a context, *rid-er*, where the marked one (dental

d) would be expected. In sum, allophonic variation is correctly predicted to go either way with Level 2 formations: be present or absent. Note, however, that it can only go one way with Level 1 formations: be present, since any Markedness constraint that dominates IO-F in (37) will also dominate Level 1 OO-F. Indeed, (33e,f) show this to be true.

Thus, all the relevant phonological differences between Level 1 and Level 2 formations are accounted for simultaneously, along with the morphological differences: irregular and unproductive, versus regular and productive, by postulating a single difference in the associational module: weak associativity in the Level 1 lexicon, but strong associativity in the Level 2 lexicon. The latter module supplants the traditional 'symbolic type' word-formation rules (WFRs), which prove incapable of adequately interacting with the phonology. As inviolable devices, WFRs can only interact with other components by means of sequential ordering. When it comes to phonology, however, neither order: before or after phonological processes, is correct, as discussed next.

One tempting possibility for ordering would be to simply assume that the Level 1 WFRs 'feed' the phonology, whence the many phonological alternations at Level 1. But, surely, underived items would then also just feed the phonology. Yet we have seen that there is in fact *more* phonology applying to Level 1 items than to underived ones: that of (33a,b) (shortening in *divin-ity*, but not in *dy:namo*; velar softening in *electri[s]-ity*, but not in *leu[k]emia*). Hence this ordering would be insufficient. One would be similarly tempted to assume that Level 2 WFRs simply *follow* the phonology, whence the lack of many phonological alternations at Level 2. However, this is insufficient as well, because on the one hand *some* phonology appears to apply to the output of Level 2 morphology, and on the other it is difficult to characterize what phonology that is. The best approximation would be that it is the allophonic (non-contrastive) phonology that applies after the Level 2 WFRs, whence (33f) *permi[ɾ]-ed*. Several problems arise here, however: (i) On the prevalent contemporary approach to phonology based on Prince and Smolensky's OT, contrastive and allophonic variations differ by their ranking schemas, not by their ordering; (ii) some allophonic phonology seems to apply even before Level 2 WFR, as first noted by Borowsky (1993), as in (33e) *cent[ɾ]-ing* or Belfast *rid-er* (w. alveolar *t*)[17]; (iii) some contrastive phonology, that which concerns the affix: *beep-[t]/bribe-[d]* seems to apply even *after* the Level 2 WFRs, as we see in the next section.

The sensible conclusion thus seems to be that WFRs apply neither before nor after the phonology, and, therefore, that there are no WFRs.

[17] Borowsky's (1993) own proposal is that there is a special 'word' level, which follows Level 1 phonology but precedes Level 2 affixation. This move seems unprincipled, and unable to relate phonological generalizations to those pertaining to morphological and semantic regularity, supporting the text conclusions.

7. Suffixes and the power of numbers

Suffixes are inherently more stable than stems. This can be seen in the fact that, in words like *satir-i:ze*, vowel shortening affects the stem, but not the suffix. Both stem and suffix are subject to OO-F on the present theory, the stem relative to the word *sati:re*, the suffix relative to other occurrences of *-i:ze* in the lexicon. In the case of the stem in *satir-i:ze*, we take the input to be associated with the word *sati:re*. Recall that the transfer of properties is asymmetrical, being stronger from base to derivative than the other way round (Section 5). Hence the base must have priority in determining the structure shared with the stem *satir-*. This is expressed by associating the relevant input (primarily, with the qualifications of the previous section which require input for all Level 1 items) with the base. In contrast, in the case of a suffix like *-ize*, there is no sense in which any instance of it is privileged over the others (at least when they are all word final, see below). Given some instance -IZE$_i$ in the lexicon fully specified in its semantics and sound structure, another partially specified instance (-IZE$_j$), where the parentheses indicate incomplete specification, will collapse into the former under GA/OO-F. Note that there must be some minimal specification/input to guarantee occurrence of the suffix even under GA. One can imagine that such minimal input could be the suffix's meaning (here roughly 'turn into/cause to become'). The question is, which would then be the first instance -IZE$_1$ which has a full input, such that other instances can then just be copies of it under GA? The answer is that, for an adult grammar, the issue is indeterminate, but also essentially irrelevant. In the adult grammar, all instances of word final *-ize* would instantiate the same vector or point in multidimensional space, and the issue of which got there first would only arise (as a minor detail) in the study of acquisition.

The higher-ranked OO-F effect with word-final suffixes than with stems will be attributed to the fact that such suffixes determine the lexical category of that word (e.g. as a verb) – a major component of the word's semantic representation. We can think of the association between the sound structure of the suffix and that component as holding special privileges, hence opposing special resistance to change. The proposed mechanism is partially similar to the one utilized above for 'exceptions', like past-tense *rang*. The proposed reason why **ringed* is excluded was that the [ae] of *rang* is part of a higher dimensional vector (specifying aspects of the verb *ring*) compared with the vector that *-ed* is part of, which merely specifies the presence of a verb. Specification of word category with a suffix can be similarly though of as an added dimension (or set of dimensions) to the vector that characterizes its sound structure, which is therefore more resilient than a corresponding one for a stem (e.g. there are more, or stronger, entailments of the type 'x ⇒ i:' for *-i:ze]$_V$* than for *sati:r-* in the word *satir-i:ze*). This accounts for the fact that, when the suffix is followed by another suffix, and hence no longer determines the lexical category of the word, it loses its privileged status, as in *character-iz-ation*, or *mand-at-ory*, where both *-ize* and *-ate* undergo regular shortening. This would be rather parallel -in fact- to denominal *ring* giving regular *ring-ed*. The reason is the [ae] of *rang* is associated not only with the sound structure of *ring*, which the

noun *ring* shares, but also – crucially – with the category 'verb' (28II above). When that category is removed, as in the noun, any association between [ae] and the sound structure *ring* is weakened (lower dimensional vector). It is thus only that weakened association that is picked up by the denominal verb *ring* (semantically akin to the noun). This, unlike the stronger association, is evidently unable to overcome the general association of past-tense with *-ed*, whence regular *ring-ed* 'construct a ring around'.

The special status of word-final affixes notwithstanding, there are many cases, like the English regular past-tense, where the suffix *rather than* the stem undergoes allomorphy: *beep-[t]/bribe-[d]*. Final consonant clusters must evidently be homorganic for voicing, but that could be achieved by fixing the stem, as in either **bee[b-d], bribe-[d];* or *beep-[t], *bri[p-t]*, whichever is the form of the suffix. What tips the scale in favor of the stem in such cases is that allomorphy is minimized globally. For stems, the overall extent of allomorphy is proportional to the number of stems: many. For an affix, that extent is proportional to one: the affix. That is, if voicing assimilation were regressive, many stems would have allomorphic variants in the past-tense. Assuming the affix to be *[t]*, this would predict *bribe/bri[p]e-t, move/mo[f]e-t, allege/alle[ ]e-t, drag/dra[k]-t, buzz/bu[s]-t*, etc. Rather than generate this massive allomorphy, the system chooses to simply alternate the suffix between [-t] and [-d]. Hence suffixes are inherently more resilient than stems, but under overwhelming numerical advantage, they will give in to stems (for earlier instances of this observation, see Burzio, 1994a, index item: Constraints, reflecting numerical or statistical factors). This effect follows from the present theory. Consider the two alternative state of affairs illustrated in (38) where, to simplify discussion, I put aside the third variant of the past-tense: [ɪd].

(38) *I. Actual* *II. Hypothetical*

a.		'past' ⇒ *[-t]*	*bribe, move, ...*	
b.	*bribe[-d]*:	'past' ⇒ *[-d]*	*bri[p-t]*:	'past' ⇒/ *bri[p]-___*
	move[-d]:	'past' ⇒ *[-d]*	*mo[f-t]*:	'past' ⇒/ *mo[f]-___*

Consider the actual situation in (38I). There is a group of verbs, like *beep[-t], brief[-t]*, etc., whose stem ends in an unvoiced consonant and which add [-t] for the past-tense. These representations will concur in generating the entailment in (Ia). In contrast, verbs like *bribed, moved*, etc. generate the entailments in (Ib), which violate the one in (Ia) – a case of affixal allomorphy. The entailments in (Ib), however, are identical. This means that, once there is a past-tense *bribe[-d]*, the past-tense of *move* will be 'attracted' to it, so that the invariance of the past-tense across *bribe[-d]/move[-d]* will partially make up for the variation across *move[-d]/brief[-t]* in terms of overall harmony, just as the invariance across *compuls-ive/repuls-ive/propuls-ive* partially makes up for the variation across *compel/compuls-ive*. In the present system, the best way to escape an attractor is always to find another (Steriade's 'lexical conservatism'). The point is that no comparable secondary attractor arises in the alternative scenario in (II). Here hypothetical *bri[p-t], mo[f-t]* alternate with their

bases *bribe*, *move*, and this may seem parallel to the alternation in the past-tense morpheme in (I). What is different, however, is that the entailments they generate, given in (IIb), do not concur, since the forms *bri[p]*, *mo[f]* are in different points in space and cannot attract each other or form an attractor together. Hence the configuration of (I) yields better overall harmony. Note that the stem allomorphy of (II) does exist, but only with small classes of items, like *leave/left* or, for the plural, *wife/wives*. For such small classes of irregulars there must be word-specific input to subtract them from the majority pattern. As usual we then find subregularity-within-the-irregularity (*leave/left* ≈ *bereave/bereft*; *wife/wives* ≈ *leaf/leaves*, etc.), i.e., 'secondary attraction', excluded with hypothetical *bri[p-t]*, *mo[f-t]* by their heterogeneity.

This confirms that morphological regularities result from summation of entailments over the lexicon, like those of (38Ib). If regular past-tense *[t/d]* or regular plural *[s/z]* allomorphy were due to 'rules', there would be no reason why the voicing assimilation should in both cases be progressive rather than regressive, since the alternative 'rules' seem perfectly equivalent.

Appeal to numbers is also the likely key to the different ranks of OO-F with Level 1 and Level 2 affixes. Level 1 affixes take relatively few stems, typically under 1,000 each, while Level 2 affixes take larger, essentially open-ended, classes, a numerical disparity which is especially conspicuous with the regular/irregular past-tenses. The relatively low-ranked OO-F that Level 1 affixes impose on their stems can be attributed to the relatively low number of entailments generated through the lexicon of the form '$\text{Affix}_i \Rightarrow / \text{W}_C$ ___', where W_C is an existing word of category C. Such entailments are actually shorthand for sets of entailments, concerning different dimensions, and, in the Level 1 lexicon, such entailments will often be generated for some dimensions but not for others. For example the word *parént*al will generate such entailment with respect to segmental structure but not stress (cf. *párent*). The Level 1 system is evidently in equilibrium that way, yielding only mild morphological regularity and strong presence of phonological effects (here regular stress). If we now imagine increasing the number of stems that an affix takes (i.e. learning new words, like 'student-al', etc.), there will come a point where the characteristics of the system will begin to shift, and likely move into a 'Level 2' configuration rather rapidly. The reason is that an increase in the number of stems will increase the number of regulars given the general proportionality. But that will increase the number of entailments that the stem equal a word, namely the rank of the OO-F associated with that affix. This will in turn further increase the number of regulars by recruiting some of the former irregulars into regularity, thus changing the proportional relation. Since enhanced regularity results in enhanced productivity (greater numbers) if the above discussion is correct, the process will be effectively self feeding. Hence the conception developed in this article predicts a critical point at which an increase in the number of stems will rapidly drive the system to regularity-productivity, yielding a quasi-categorical type of distinction like the one observed between Level 1 and Level 2 affixes. It also sheds light on the fact that OO-F constraints concerning different dimensions seem to re-rank up in bulk when going from Level 1 to Level 2. The question here is not only why invariance over

different dimensions clusters within individual items, as in e.g. *drí:ver-less*, where both vowel-length and stress are maintained from *drí:ver*. Here, Gradient Attraction (21) will yield that directly: once invariance is achieved on one dimension, there will be more pressure to achieve it on others. The question is rather: where does the pressure for invariant stress in, e.g., *éffort/éffort-less* come from, given the invariance for, say, vowel length in *cri:me/cri:me-less*? The answer is that stem-invariance in each dimension is a property associated with the structure of the affix. So, if we take invariance for vowel length to hold, that will be in the form of the entailment '-less $\Rightarrow$ / $W_{\text{vowel-length}}$ ___' (the stem must equal an existing word with respect to vowel length). Invariance in vowel length will make it more likely for stress invariance to also be achieved in a multi-dimensional case like *drí:ver-less* (just GA). This representation will then contribute to the entailment '-less $\Rightarrow$ / W_{stress} ___' (the stem must equal an existing word for stress) built into the affix, which in turn will have an effect on *éffort-less*, despite the fact that, in itself, this word does not implicate vowel-length.

In sum, the present conception is able to predict that there will be some tendency within lexical systems to organize themselves along one of two lines: one in which the effects of memorization are prevalent; and one in which the effects of association are prevalent, indeed as we seem to witness in the English Level 1/Level 2 distinction, and – by specific instantiation – in the one between regular and irregular past-tense. Although the above discussion provides no real means to quantify that tendency and is crude in various ways, it nonetheless suffices to warrant the conclusion that it would be incorrect to postulate two independent systems – a 'dual' route. In essence, the reasons are of two types. One is general and conceptual: the 'dual route' hypothesis has more the character of a question than that of an answer. Why should the language faculty consist of two unrelated architectures? The other type of reason is specific and empirical. It is only by postulating a single type of architecture that the effects of phonology and morphology can be controlled simultaneously in accordance with the inverse relationship noted in (1) above.

8. Conclusion

Work in theoretical linguistics has traditionally sought to account for the interaction of morphology and phonology. I have argued that one important aspect of that interaction is the generalization in (1): morphological and phonological regularities are inversely correlated with one-another. The theoretical model dominant through the 80s and early 90s, the 'Lexical Phonology' of Kiparsky (1982a, b) had succeeded in capturing that correlation only in part and by means that were ultimately stipulatory: the assumption that, at Level 2, rules of the phonology get turned off, making the phonology appear 'irregular'; and the assumption that any output of Level 1 word-formation must be a bona-fide word, thus barring bound stems at Level 2, and hence making the morphology look more 'regular'. In the transition from that work to the psycholinguistics debate on the English past-tense, the line of attack to the problem of morpho-phonology interaction was substantially weakened – from not

fully resolving it, to ignoring it. The goal of this paper has been to revive that line of attack by re-introducing phonology into the picture.

Virtually by definition, 'irregular' morphology must involve some form of memorization, while 'regular' morphology involves some form of calculation. Much work in psycholinguistics has shown that, indeed, different mental resources are involved, exactly as expected given the distributional evidence. The point of significance is that the English lexicon – and one presumes that of other languages – exhibits a relatively abrupt transition from a system that is highly irregular (Level 1), to one which is highly regular (Level 2). Prima-facie, this might support the view that there are two independent systems: a 'dual' route. I have argued that phonology forecloses that theoretical option. It is only by construing what we call 'morphology' as a set of violable associations under a single architecture that the generalization in (1) can be captured: as the strength/rank of those associations ratchets up, the effects of the other two components of the system, memorization and phonology are simultaneously suppressed, making morphology look 'regular' just when phonology is 'blocked'/made to seem irregular.

I have outlined an associational theory of morphology that extends the notion of output-to-output faithfulness originally introduced in Benua (1997) and, under the terms 'Metrical consistency'/'Anti-allomorphy', in Burzio (1991 et seq.), arguing that the lynch-pin of the associational system is the simple and natural assumption that mental representations form sets of entailments – a principle of neural, rather than symbolic, computation. Under that assumption, representations effectively attract one-another, yielding both the type of organization that we call 'morphology' and phonological aberrations due to 'transfers' across morphologically related words. The abrupt transition between irregular and regular morphology, once motivation for a 'dual route' approach, follows in this system from the fact that regularity is 'self-feeding', due to the obliteration of the distinction between representations and constraints: regularities across the lexicon translate into concurring entailments whose combined effects yield more regularity, and so forth.

The present system extends the framework of Prince and Smolensky's 'Optimality Theory', which provides a 'parallel' characterization of phonology in terms of violable constraints, by providing for a 'parallel' view of morphology, as in Bybee's 'Network' model, and hence for a 'parallel' relation of phonology and morphology as well (already dormant in Burzio, 1994a). In eliminating the distinction between the grammar (constraints) and its outputs (representations), the present system takes a turn from generative tradition, which had consistently seen adult knowledge as a one-way relation from grammar to outputs, reserving the opposite relation: from outputs to grammar only for language-acquisition.

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